COLLECTED REPRINTS

FROM THE

DEPARTMENT OF EXPERIMENTAL SURGERY

NEW YORK UNIVERSITY

and

BELLEVUE HOSPITAL

MEDICAL COLLEGE

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Department of Experimental Surgery

OF THE

NEW YORK UNIVERSITY
AND BELLEVUE HOSPITAL
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Department of Experimental surgery.

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Contributors to Volume 2 under the Department of Surgery, New York University and Bellevue Hospital Medical College.

George David Stewart, M.D., F.A.C.S.
(*Professor of Surgery, New York University and Bellevue Hospital Medical College, and Director of the Third Surgical Division, Bellevue Hospital.*)

William Chittenden Lusk, M.D., F.A.C.S,
(*Professor of Clinical Surgery and Assistant Surgeon, Bellevue Hospital.*)

Charles Goodman, M.D., F.A.C.S.
(*Clinical Professor of Surgery.*)

William Howard Barber, A.B., M.D., F.A.C.S.
(*Director of Laboratory of Experimental Surgery and Assistant Surgeon, Bellevue Hospital.*)

John William Draper, B.S., M.D., F.A.C.S.

Harry Belleville Eisberg, MD.

John Joseph Nutt, M.D.

Jerome Morley Lynch, M.D., F.A.C.S.

William Landram McFarland, M.D.
(*Voluntary Associates in Experimental Surgery.*)

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The Gastric Hypermotility Associated with Diseases of the Gallbladder, Duodeum, and Appendix

A CLINICAL AND EXPERIMENTAL STUDY

GEORGE DAVID STEWART, M.D.
AND
WILLIAM HOWARD BARBER, M.D.
NEW YORK

THE GASTRIC HYPERMOTILITY ASSOCIATED WITH DISEASES OF THE GALLBLADDER, DUODENUM, AND APPENDIX

A CLINICAL AND EXPERIMENTAL STUDY *

GEORGE DAVID STEWART, M.D.
AND
WILLIAM HOWARD BARBER, M.D.
NEW YORK

The stomach in a general way is recognized by the diagnostician as the spokesman for disease anywhere within the abdominal cavity, but particularly for organic disturbances of the gallbladder, duodenum and appendix. It is not only very difficult to ascertain which of these three organs is afflicted, but it is often impossible to free the stomach entirely from suspicion of disease. It becomes, therefore, of the utmost importance to the abdominal surgeon to have some system of classifying gastric motor pictures by which a pathologic condition of the stomach is established or eliminated, so that he may determine what organ is pathologic if the stomach is normal, and to what extent the diseased organ is involved.

There are obviously two means of studying the reflex activity of the stomach: the review of recent hospital records, and the duplication, as far as possible, of the human disease equations in the experimental laboratory. The reports of gallbladder, duodenum, and appendix cases in the Third Division, Bellevue Hospital, from 1911 to the present time, have been reviewed, and from these have been selected only those cases with full roentgenographic reports based on complete gastro-intestinal examination confirmed or modi-

* From the Department of Surgery, New York University and Bellevue Hospital Medical College.

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fied by direct inspection of the open abdomen. In those few instances in which the roentgenographic diagnosis did not correspond to the actual findings at operation, the error, which was one of inference and not of observation, was corrected. For example, a persistent irregularity in the outline of the stomach has been called organic and, at operation, the stomach appears absolutely normal; this same stomach is known to functionate normally in terms of emptying and of secreting; it is obvious that the "irregularity" described as organic may be either organic or inorganic; and, on the foregoing basis, the roentgenographic description is changed from "probable adhesion" or "scirrhus involvement" to gastrospasm. The pathologic findings have been purposely omitted; their significance, as far as the stomach function is concerned, may be the measure of the stimulation or depression of the stomach.

TABLE 1.—SURGICAL GALLBLADDERS

	Case No.		Operation		Roentgen-ray Finding for Stomach
1.	C.	120	Cholecystectomy *	(W)	Hyperperistalsis
2.	C.	123	Cholecystectomy	(S)	Normal
3.	GD.	8	Division of Adhesions	(D)	Hyperperistalsis
4.	C.	15	Cholecystectomy	(S)	Hyperperistalsis (1st exam.) Gastrospasm (2d exam.)
5.	C.	19	Cholecystectomy	(S)	Hyperperistalsis
6.	GD.	20	Cholecystectomy	(S)	Normal
7.	GD.	22	Cholecystectomy	(D)	Hyperperistalsis
8.	C.	78	Cholecystectomy	(D)	Pylorospasm (diffuse)
9.	C.	80	Cholecystectomy	(D)	Gastrospasm
10.	C.	107	Cholecystectomy	(S)	Normal
11.	C.	110	Cholecystectomy	(S)	Gastrospasm
12.	C.	15	Cholecystectomy	(S)	Hyperperistalsis
13.	C.	1	Cholecystectomy	(S)	Pylorospasm
14.	C.	7	Cholecystectomy	(S)	Normal
15.	C.	9	Cholecystectomy	(D)	Pylorospasm
16.	C.	25	Cholecystectomy	(D)	Normal
17.	C.	28	Cholecystectomy	(D)	Normal
18.	C.	30	Cholecystectomy	(D)	Pylorospasm
19.	C.	36	Cholecystectomy		Hyperperistalsis

* In Tables 1, 2, 3 and 4, the capitals enclosed in parentheses denote the operators: Stewart, Douglas, Cramp, Barber and Walker, designated by S, D, C, B, and W, respectively.

From these surveys, it appears that the percentages of hypermotility, hypomotility and normal gastric function in gallbladder disease (meaning cholecystitis with or without cholelithiasis) are: hypermotility, 68.4; hypomotility, 0; normal, 31.6; in diseased duodenums (duodenal ulcers): hypermotility, 75; hypomotility,

12.5; normal, 12.5; and in "chronic appendicitis": hypermotility, 55; hypomotility, 0; normal, 45.

There are in this, as in any similar review of case statistics, many sources of error. A few of these are: the general condition of the patient; the emotional state of the patient at the time of the roentgen-ray examination; the irritability of the stomach at the time of the

TABLE 2.—SURGICAL DUODENUMS

	Case No.		Operation		Roentgen-ray Finding for Stomach
1.	U.D.	67	Gastro-enterostomy	(S)	Hyperperistalsis
2.	U.D.	70	Gastro-enterostomy	(B)	Hyperperistalsis
3.	U.D.	71	Gastro-enterostomy	(S)	Normal
4.	U.D.	74	Gastro-enterostomy	(S)	Hyperperistalsis
5.	U.D.	47	Gastro-enterostomy	(S)	Hyperperistalsis
6.	U.D.	51	Gastro-enterostomy	(S)	Hyperperistalsis
7.	U.D.	54	Gastro-enterostomy	(S)	Hyperperistalsis
8.	U.D.	55	Gastro-enterostomy	(D)	Hyperperistalsis

TABLE 3.—SURGICAL APPENDIXES

	Case No.		Operation		Roentgen-ray Finding for Stomach
1.	C.A.	246	Appendectomy	(B)	Hyperperistalsis
2.	C.A.	255	Appendectomy	(S)	Normal
3.	C.A.	256	Appendectomy	(S)	Hyperperistalsis
4.	C.A.	264	Appendectomy	(S)	Normal
5.	A.A.	471	Appendectomy	(D)	Gastrospasm
6.	C.A.	234	Appendectomy	(C)	Hyperperistalsis
7.	C.A.	201	Appendectomy	(W)	Normal
8.	C.A.	207	Appendectomy	(D)	Normal
9.	C.A.	107	Appendectomy	(S)	Normal
10.	C.A.	112	Appendectomy	(D)	Normal
11.	C.A.	121	Appendectomy	(W)	Normal
12.	C.A.	122	Appendectomy	(D)	Hyperperistalsis
13.	C.A.	90	Appendectomy	(D)	Hyperperistalsis
14.	C.A.	145	Appendectomy	(S)	Hyperperistalsis
15.	C.A.	151	Appendectomy	(S)	Pylorospasm (?)
16.	C.A.	153	Appendectomy	(S)	Normal
17.	C.A.	155	Appendectomy	(S)	Normal
18.	C.A.	60	Appendectomy	(C)	Hyperperistalsis; pylorospasm
19.	C.A.	64	Appendectomy	(C)	Gastrospasm (?)
20.	C.A.	76	Appendectomy	(S)	Hyperperistalsis

examination, and the presence or absence of other diseased foci in the body. These factors should enter into the accompanying tables as variables; and the extent to which they affect the motor pictures of gallbladder, duodenal and appendix-stomach cases should appear in the variations in each set of cases. Hypermotility is evidently the rule in each group; hypomotility and normal stomach, being variables, indicate, for example, malnutrition, depression, a phase of gastric inactivity,

or the presence of two or more associated lesions. Some of these appear on the hospital charts; many, obviously, do not and cannot. A possible effect of two simultaneous lesions may be seen in Table 4.

TABLE 4.——SURGICAL GALLBLADDER AND APPENDIX

Case No.	Operation	Roentgen-ray Finding for Stomach
1. (V.6) C.18	Appendectomy; cholecystectomy	(S) Normal
2. C.19	Appendectomy; cholecystectomy	(S) Normal

The appendix group represents the greatest degree of variation. Hirsch, whose opinion is based on an enormous experience in such cases, holds that the rule is hypermotility for the stomach after chronic appendicitis. The "normal" percentage of 45 is probably due to the fact that a large proportion of the appendixes were either normal or functionally inactive. This attitude is well depicted in Moschcowitz' report[1] on chronic appendicitis (1,500 cases) in which the reality of chronic inflammation of the appendix existing at all is questioned. On this basis, the 55 per cent. of appendixes giving hypermotile stomachs in Table 3 represent acute exacerbations of appendicitis. "Chronic appendicitis" in a fair percentage of instances is accompanied by adhesions or scar tissue from previous attacks of acute appendicitis which, in themselves, have been shown to influence the tone and motility of the duodenum and stomach. A very recent example (Fig. 1) of postappendical adhesions involving the terminal ileum, cecum, uterus and right ovary, associated with spasm of the second portion of the duodenum and with diffuse pylorospasm giving a twenty-seven-hour end-ileal retention and a six-hour gastric residue, illustrates this relationship. It is, no doubt, fair to conclude that the probabilities of gastric hypermotility as described above in the presence of diseased gallbladders, duodenal ulcers, and chronic appendicitis of the mean case, as seen at Bellevue Hospital, are, respectively, 68.4, 75 and 55.

Occasional experience with the contracting stomach in the open surgical abdomen has been greatly supplemented by similar experimental studies on the mammalian stomach. A recent paper[2] records a late sum-

1. Moschcowitz, E.: Ann. Surg. **63**: 697-714 (June) 1916.
2. Barber, W. H.: Ann. Surg. **69**: 271-277 (March) 1919.

mary of these observations. Table 5 comprises a list of canine experiments. Each dog, which was to all appearances a normal animal, was prepared for operation by having breakfast withheld and by being given a hypodermic injection of morphin; he was etherized by

Fig. 1.—Diffuse pylorospasm secondary to postappendical obstruction. There was no bismuth to be seen beyond the obstruction in the pylorus. The bowel was wholly free from bismuth.

means of the Janeway intratracheal apparatus, which keeps the subject evenly under the anesthetic during the course of the experiment; and his abdomen was opened in the upper half so as to expose the stomach and duodenum with the least possible trauma of handling and of instruments. Under these conditions,

the stomach was watched for the appearance of the normal two-cycle contractile phase. When these contractions appeared, which might be at once or after the lapse of half an hour, or if the organ was not properly irritable or not irritable at all (these animals had to be excluded), the stomach was considered to be approximately normally contracting, and any changes in these contractions produced by parietal and visceral traumas were carefully noted. In one instance, a non-

Fig. 2.—Duodenospasm secondary to postappendical obstruction, with retention in stomach and duodenum, as shown by the retained bismuth.

irritable stomach was made to contract by gently blowing air into it through an esophageal catheter. This relation of the stomach contractions to rise in intragastric pressure is especially represented in the paper mentioned.[2] In these experiments, the latency of gastric response to extrinsic stimulation corresponded roughly to the latent period of contraction for involuntary muscle. This interval was often three minutes, but varied from less than one minute to ten minutes. In a fair proportion of the animals, it was impossible

to describe normal contractions for the stomach at all or to arouse in them any reaction to extragastric stimuli. These animals are not included in Table 5.

TABLE 5.—EXPERIMENTAL SERIES

Experiment No.	Organ Irritated	Effect on Stomach	Effect on Duodenum
10	Stomach	Gastrospasm	
	Duodenum		Duodenospasm
11	Parietal peritoneum	Peristalsis inhibited	
	Cecum (appendix)	Pylorospasm	
	Gallbladder	Pylorospasm	
	Pylorus	Retrostalsis; hypermotility; gastrospasm	
18	Gallbladder	Hypermotility	
	Stomach	Hypermotility	
	Duodenum		Duodenospasm
20	Cecum (appendix)	Gastrospasm; pylorospasm	
	Gallbladder	Retrostalsis	
21	Stomach	Gastrospasm	
12	Gallbladder	Retrostalsis	
	Duodenum	Hypermotility	
32	Intestine	Hypermotility	
	Duodenum	Pylorospasm	
	Gallbladder		
	Stomach		
33	Duodenum	Retrostalsis; pylorospasm	
33	Gallbladder	Retrostalsis; hypermotility	
	Parietal peritoneum	Dilatation	
35	Gallbladder	Hypermotility; pylorospasm	
	Small intestine	?	
	Duodenum	Hypermotility; pylorospasm; incisura	
40	Parietal peritoneum	Dilatation	
	Gallbladder	?	
	Appendix	Hypermotility	
41	Gallbladder	Hypermotility	
	Parietal peritoneum	Peristalsis inhibited	
61	Gallbladder	Hypermotility	
68	Appendix; duodenum; gallbladder	Hypermotility	
69	Appendix; duodenum; gallbladder	Hypermotility	

It should be added that all these experiments were carried out before a review of the hospital records was undertaken—which should add weight to the striking correspondence in the two data. On the basis of these experiments, the motor functions of the stomach after gallbladder stimulation, in percentages (eleven cases) are: hypermotility, 61.5; hypomotility, 0; normal, 15.4; retrostalsis, 23.1. After traumatization of the duodenum (six cases), the gastric motility is: hypermotility, 66.7; hypomotility, 0; normal, 22.2; retrostalsis, 11.1; and after clamping of the appendix (cecum) (four cases): hypermotility, 100; hypomotility, 0; normal, 0; retrostalsis, 0.

In comparing the two series, it will be noted that the variables: general condition of the patient, the emotional state, the gastric irritability, and the possibility of other diseased foci occurring at the same time, enter into both the human and the canine groups, although it is no doubt true that in the latter these elements are better controlled. This is particularly applicable to the appendix cases in which the potential appendix even after pathologic examination, in many instances, in the hospital series remains problematic, while there is no doubt of essential injury to the dog's cecum which is held in a tightly locked crushing clamp. Retrostalsis appears in the experimental but not in the clinical series. This is probably accounted for by the fact that patients who are vomiting are not submitted to roentgen-ray examination, although Hirsch reminds us that occasionally he has seen this phenomenon take place during fluoroscopic examination of the stomach. On the other hand, if vomiting did occur at the moment the roentgenogram was taken, it is probable that the direction of the wave from the pylorus toward the cardia could not be ascertained. Antistalsis is seen in the canine group because the animals are studied under conditions of acute traumas which provoke vomiting in the anesthetized creature. The human cases were chronic; the mammals correspond to acute types; but when it is remembered that the patients present themselves during their periods of acute suffering, this apparent dissimilarity loses weight.

It is apparently impossible, in the light of our present knowledge, to exclude absolutely, without direct examination, a pathologic condition of the stomach in the reflex type of individual under discussion. The roentgenologists are working on this problem, and it is hoped that something will come of it. From experience with the surgical stomach, as presently outlined, one is led to conclude that the incisura or localized gastrospasm, which may be a response to direct or to extragastric traumas, should practically always be associated with the gastric lesion and should relatively infrequently accompany the diseased gallbladder, duodenum and appendix. Given the pathologic grouping of individuals that the roentgenologist sees, it is probably true that the incisura is not infrequent after lesions of the gallbladder and duodenum, and not uncommon

after appendicitis. What has been said of the incisura probably largely applies to spasm of the pyloric sphincter. On the other hand, diffuse pylorospasm very infrequently follows clinical and experimental disease of the gallbladder, duodenum and appendix.

To estimate in advance from a study of gastric motor physiology to what degree the suspected organ is diseased may not be out of the range of human possibility.

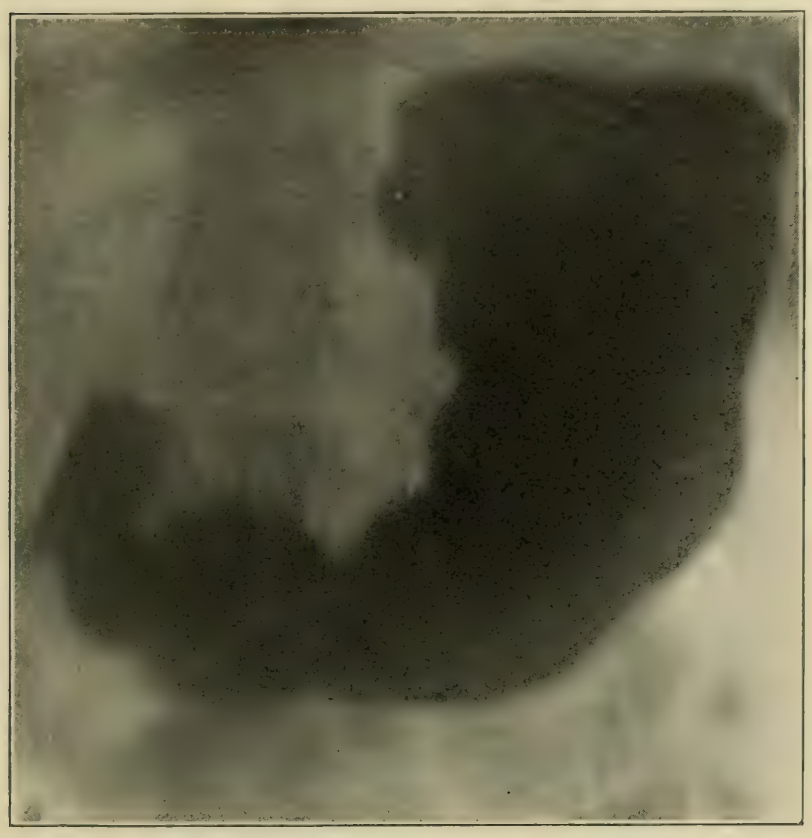

Fig. 3.—Stomach hyperperistaltic and to the right in the presence of gallbladder disease.

A closer cooperation between the roentgen-ray and experimental laboratories, operating room, and pathologic laboratory may work to this end. There are two investigations that throw some light on a means of indicating the diseased organ and the extent of disease: one is that of antistalsis in the stomach, and the other is the selective response of the fundus and pylorus to extrinsic stimulation. Both of these problems are undergoing further study.

SUMMARY

1. For the past eight years, the records of chronic cholecystitis, with or without cholelithiasis, duodenal ulcer, and chronic appendicitis bearing roentgen-ray notes on the gastric motor function and verified by open operation, disclose gastric hypermotility for gallbladder disease in 68.4 per cent., for duodenal ulcer in 75 per cent., and for chronic appendicitis in 55 per cent. of cases.

2. Experiments purposely carried out in the open surgical abdomen antedating this clinical review give hypermotility for gallbladder disease in 61.5 per cent., for duodenal trauma in 66.7 per cent., and for appendix disease in 100 per cent. of experiments.

3. The motor characteristics of surgical lesions of the stomach are the incisura, and pylorospasm (pyloric-sphincter-spasm) in that they probably more frequently occur in the presence of essential disease. Diffuse pylorospasm appears very often "reflexly."

ABSTRACT OF DISCUSSION

Dr. Anthony Bassler, New York: Gastro-enterologists seem to have a very hazy idea as to what tonus really is. Some work on tonus has been done recently by Dr. Byrne of Fordham University, presenting tonus in a way which to me is practicable and understandable. Tonus may be divided into two parts, a postural status, which may be designated as the jel of the muscle. As I stand here without making any effort my muscles are in a state of jel. Then there is an additional element, the element that is added by the nervous system, mainly the cerebrospinal system. That represents the active part of tonus. I am going to speak particularly on the subject of hypermotility. I notice that in the statistics here, there are in the first statistics, gallbladder 68 and appendix 55 per cent.; whereas in the second statistics the gallbladder is reduced to 61 per cent. and the appendix elevated to 100 per cent. In my opinion, hypermotility is of no diagnostic significance in gallbladder pathologies. It is of significance in disease of the stomach, duodenum and appendix. The reason it should not be considered in gallbladder cases is anatomic as well as clinical. The nerves of the stomach come from both pneumogastrics and sympathetics, containing medulated and nonmedulated fibers. Here the sympathetic system is a complex of both kinds of fibers. The nerves that supply the stomach come from the gastric plexus and these also supply

the upper level of the duodenum—thus hypermotility in duodenal ulcer. The right vagus is the more important in this connection, in that it supplies fibers to the posterior wall of the stomach, the solar plexus, spleen, pancreas, intestine, midcolon and suprarenal. Thus the stomach has direct connection with the appendix as is the fact with the duodenum. The nerves of the gallbladder come from the solar plexus through the hepatic plexus, which is in the lesser omentum in company with the bile ducts, hepatic artery and portal vein. It inosculates with the left vagus but this only supplies branches to the anterior surface of the stomach over a very limited area of the stomach—thus the gallbladder is very indirectly connected with the stomach and then only in small part. I feel definitely that the roentgen-ray teaching of hypermotility of the stomach as a symptom of gallbladder pathology should be eliminated.

Dr. R. Walter Mills, St. Louis: I do not understand what Drs. Stewart and Barber mean by hypermotility, whether they speak of total gastric motility, initial motility, or fractional motility, which, by the way, may be the method of the future. In a series of 2,500 cases in which I determined the exact time of total gastric motility after a standard roentgen-ray test meal to within seven minutes, no such findings as have been given by the present investigators were obtained. For instance, in that series there were fifty-three cases of gallbladder disease and 25 per cent. of them showed hypomotility instead of hypermotility, as indicated by a six-hour residue after the barium meal. In a series of 203 cases of duodenal ulcer, 49 per cent. showed hypomotility in the sense of total motility. In appendicitis, motility was practically that of a series of one thousand cases without any organic or marked functional disturbance. A great factor in estimating gastric motility is the type of individual. For instance, in the two extremes of bodily habitus, the stomach of the asthenic often will not clear of an average contrast meal in six hours. I have seen the same meal emptied from the stomach of the other extreme of type, the hypersthenic, in one and one-quarter hours. These are extremes. All motilities between these two form a gradient. If all persons are grouped in four types, hypersthenic, sthenic, hyposthenic and asthenic, their stomachs will be found to empty about as follows: The hypersthenics in four hours, the sthenics in four and one-half hours, the hyposthenics in five hours and the asthenics in five and one-half hours. The work of Dr. Alvarez on visceral neuromuscular activity as related to peristalsis and motility indicates that many gastric hypomotilities where the lesion is within the stomach, are the result of inhibition rather than to crippling of the gastric expulsive mechanism.

Dr. I. O. Palefski, New York: The conclusion reached by the authors is generally recognized among roentgenologists—that hypomotility is usually found in intestinal cases. However, I do not believe we can take that as a clinical application, because usually gallbladder cases that come under observation show that the predominating feature is that of gastro-intestinal stasis. At Bellevue Hospital, it has been my invariable experience from the clinical point of view that the reports showed hypomotility; while after a really mixed meal there is, perhaps, in about 80 per cent. of cases a residue after six or seven hours. I do not believe we can test the gastric motility through barium. In order to test the motility we must take into consideration the factors which enter into motility or the evacuation—the normal acidity, the normal stimulation. I feel that this is a very important point in gastro-enterology and it requires team work on the part of the gastro-enterologists as well as the roentgenologists to come to a conclusion.

Dr. Van Valzah Hayes, New York: It seems to me that we do need a more thorough method, a more satisfactory method of testing the motility of the stomach. Just one example:

Recently a patient came to my office. I took an ordinary test breakfast and to my surprise found present pieces of vegetable eaten at dinner the night before. The patient was then sent for roentgen-ray study and the barium was given. The roentgenologist reported that "the stomach evacuates itself rapidly and is almost completely empty at two hours."

Dr. G. A. Friedman, New York: I would like to ask Dr. Stewart whether he has had occasion to examine his patients roentgenographically after their appendixes or gallbladders were removed, and whether the roentgen findings in regard to motility of the gastro-intestinal tract were different from those found before operation. If the disturbance in motility was due to the diseased appendix or to the diseased gallbladder, normal motility should have established itself after the surgical procedures. If, however, the postoperative roentgen findings were identical with the preoperative findings, it may then be questionable whether the altered motility discovered previous to operation was really due to the pathology in the appendix or gallbladder. May it not be possible, then, that the disturbance in nerves regulating the musculature was the primary factor for the disturbance in motility?

Dr. William Howard Barber, New York: In regard to the connections of the extrinsic gastric nerves with "reflex" gastric motility: keeping in mind the anatomy, as Dr. Bassler has described it, it is very difficult to interpret the effects on stomach tonus produced by traumatizing, clinically or experimentally, extragastric tissues; it is difficult

to affirm positively that such effects are vagus or splanchnic. These nerves have been divided in the chest and in and about the stomach. From these experiments, it appears that the vagus nerve carries motor fibers to the fundus and inhibitory branches to the pyloric part. Appendical, duodenal and gallbladder irritation in the present series is most often associated with gastric hypermotility. One occasionally sees in the course of an operation, gastric motor waves followed (as the traumatism of handling continues) by fundic relaxation and, later, by pyloric relaxation or total dilatation. These changes may be due to the loss of vagus control or to the stimulation of the sympathetic.

Under the head of hypermotility are included the gastric spasms. Pylorospasm may be confined to the anatomic sphincter or to the pyloric end of the stomach. It is believed that the spasms are qualitatively identical with hypermotility. Increase in force characterizes the spasmodic contractions, but increase in rate characterizes the cycles in hyperperistalsis. Hypermotility must be differentiated from "emptying time" for it is evident that a forcibly contracting stomach may be associated with early emptying or retention accordingly whether there is pyloric relaxation or obstructive pyloric spasm. For this reason, the gastric "motor" meal is not a motor meal at all but significant of the time of gastric emptying. Of course, the anatomic types, spoken of by Dr. Mills, are to be considered among the variables influencing the tone and motility of the mean stomach. The choice of the opaque meal and the interpretation of the roentgenograms have been left with the roentgen-ray department. The gastric motor function following operation was largely a personal equation. It is to be expected that this improves as the general condition of the patient improves.

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GAS AND THE MOTILITY OF THE SURGICAL STOMACH*

BY W. HOWARD BARBER, M.D.
OF NEW YORK
(From the Department of Surgery, New York University and Bellevue Hospital Medical College)

A CERTAIN amount of gas undoubtedly always exists in the normal stomach although there may be no consciousness of its being there and there is obviously a purposeful relationship between this intragastric gas and the stomach's motility. Throughout the stomach and intestinal tract this contained gas apparently becomes an almost indispensable medium for the origination and perpetuation of the peristaltic contractions and for the coördination of the colonic, enteric and gastric waves with one another. Whenever an irritable focus arises at any site along this visceral tract or in any coördinated system of intra-abdominal organs the whole functional picture changes, and particularly the expression of the stomach's activity. Under these conditions, intragastric gas, although it may not have increased in quantity, becomes superfluous and often burdensome and, by the patient, is blamed as the immediate cause of his illness.

The question of vagotonia and sympathicotonia is again brought up in the discussion of the surgical stomach. The objections to this nomenclature are: (1) The innervations by the autonomous and sympathetic fibres are not understood, much less generally agreed upon; and (2) it needlessly revives the fundamental consideration of the origins of disease: whether disease is purely functional and then morphological or whether morphological and then functional. The solution of the etiology of disease is a philosophical one and peculiar to each individual. Surgery is concerned with the elimination of the functional disorders and applies itself to the material causes of disease. The stomachs described in this paper can only act in their own terms if they act at all. Certain stimuli are set in motion by producing diseased conditions of the appendix, gall-bladder, duodenum, or stomach, and the stomach responds with changes in motility. It is not improbable that purely chemical causes may bring about diseased conditions in these organs, that the physiology of the organs of internal secretion may have allowed these chemical causes to work harm to the individual, and, even more remotely, that inheritance may have been responsible for the insufficiencies of certain ductless

* This paper was undertaken to answer questions that have come up in the course of surgical teaching; such as, "Why hypermotility in some instances and pylorospasm in others of chronic appendicitis?" "Why epigastric cramp in gall-bladder disease?" "What gives rise to the incisura in the normal stomach?" "The significance of gas in stomach contraction?" etc.

glands, but, in the rational treatment of morbid processes, one has to start somewhere and surgery elects to attack the material causes.

However responsive the stomach's behavior may be to disturbances elsewhere within the abdominal cavity it does not appear that relaxation and dilation will progress to dangerous limits. The few and isolated cases reported seem to be instances in which the structure of the stomach has been impaired. Gill's[1] case apparently comes the nearest being a real spontaneous rupture of a normal stomach, but even here, during the forty-eight hours of gastric dilation, two doses of atropin had been administered. The responsive nausea, the possibilities of personal idiosyncrasy and of selective drug action are so great that a negligible depressive action of the drug can scarcely be excluded. Batelli,[2] in 1896, showed that atropin may be followed by a loss in gastric tonus and contractions, in vagus excitability, and in splanchnic action. A normal stomach is protected against dangerous distention by eructation and vomiting.

The origin of the stomach gas is in doubt. The possibilities are obviously air that has been swallowed, duodenal gas that has been eructated through the pylorus, as bile and duodenal secretions are eructated, or, finally, an end-product of stomach chemistry or of gastric metabolism. The analyses of stomach gas correspond with those of expired air and this similiarity suggests atmospheric air as its basis.

The functional significance of this gastric gas has been studied clinically as well as experimentally. From recent surgical writings, it is apparent that observations are being made during clinical operations upon the motility of the stomach, intestine and ureter. The common bile-duct belongs in the same category of hollow viscera but its peristalsis is probably still of physiological interest only. Ureteral peristalsis has been called attention to as a convenient means of differentiating the ureter from a blood-vessel. Gastrospasm and enterospasm are frequently seen after handling these organs in the human subject, and gastric peristalsis has often been displayed and its relationship to peritoneal traumata brought out in clinical teaching. The pyloric and ileocolic sphincters, under the same nervous control as the rest of the hollow viscera, are frequently investigated in respect to size and tone. It is probable that these findings very well correspond with the fluoroscopic and X-ray studies as well as with the observations upon experimental animals. This is very important because it makes possible more prolonged and better controlled studies of human surgical problems upon brute animals.

In order to bring out the relationship of stomach gas pressure to stomach contractions, four experiments were performed upon the canine stomach during the digestive period and under morphine-ether narcosis. The intragastric tension was measured in millimetres of water on a manometer connected up with the anterior wall of the stomach. The traumatization of introducing the canula tip increased the force and, pos-

sibly, the rate of the peristaltic contractions for the first few seconds but the waves continued on by the canula to the pylorus. Air, forced into the stomach, raised the pressure of the contained air and registered on the manometer.

Experiment 207.—A normal two-cycle stomach with peristaltic contractions recurring every twenty seconds and with an intragastric pressure of 30 mm. Each respiration raised the pressure 10–20 mm. and each prostaltic wave 5–15 mm. The greatest rise occurred at the time the proximal wave was at the pylorofundic junction and the distal one was at the pyloric sphincter.

The pressure was raised from 30 to 90 and the variations ranged between 85 and 100; these variations were respiratory only for the peristalsis had disappeared.

The pressure was lowered to 70, to 60, to 50 and to 40, successively, before peristalsis was observed again in the stomach. When reduced to the normal 30 the waves appeared as above with the same periodicity but with slightly reduced force.

There was heard at this time and through the remainder of the experiment a distinct pyloric rumbling, fairly low-pitched, synchronous with the appearance of the through-prostaltic wave at the pylorus.

The stomach was emptied of its gas, and, while the contractions continued every 20 sec., they were weak, and the gurgling disappeared.

At 15 and 25, the soufflé reappeared. At 50, the motility was pyloric, with an occasional through-wave and gurgling. At 70, 80 and 130, "through" waves persisted, but with irregularity in rhythm and force, and the intrinsic pyloric motility had disappeared. Respirations continued to exert their influence, very strong inspiratory efforts forcing the water out of the manometer.

Conclusion.—Waves of gastric contractions persist during a given activity period whether the intragastric air pressure is normal: 30, hyponormal: 15, zero, or greatly increased: 70, 80, 130. In a normal animal the strongest contractions appear to coincide with the normal intragastric gas pressure, 30.

These findings agree with those of Cannon [3] on the cat, the conclusions of which, he summarizes as follows: "Gastric peristalsis results from tension produced by internal pressure acting on the tonically shortened gastric musculature, for (1) distention of the inactive stomach causes peristalsis when the musculature is tonically shortened but not when it is relaxed; (2) considerable intragastric pressure (sustained tension) prevails in the stomach manifesting peristalsis; (3) within limits peristalsis is augmented or weakened as intragastric pressure is experimentally increased or decreased."

Surgery recognizes two points in intragastric pressure: that which exceeds the physiological limit and that which falls below that limit. The former is known as dilation of the stomach and the latter is a partially collapsed stomach occurring in perforating ulcer and traumatic rupture. From the above observations, it appears that the motility is diminished whether the pressure is abnormally high or low. In acute dilation and in perforating ulcer the immediate treatment outweighs all other considerations, but in the chronic stomachs with abnormal pressures and abnormal motility, the treatment of the causes of these distentions or motor changes is desirable.

The etiological treatment of dilation, whether prolonged as in mechanical closure of the pylorus or spasmodic as in the so-called "stomach-reflex" conditions, involves the study of a great number of possible causal factors. Whatever the origin of the gastric spasms, whether they be "reflex" or due to changes in intravisceral pressure (Cannon), or due to changes in the gradient of contractility (Alvarez [4]), or whether the spasms depend upon one or more of these conditions as associated factors, symptoms of distention are complained of by the patient and abnormal motility is observed by the examiner. The motility may be increased, decreased, reversed, or spasmodic.

The significance of pylorospasm differs with the conception of "pylorus." If by "pylorus" is meant the projecting edge of the pyloric end of the stomach into the duodenum, then pylorospasm is limited to an arbitrarily small segment of the stomach. If by "pylorus" is meant the pyloric end of the stomach or the "surgical pylorus," then pylorospasm becomes a diffuse spastic contraction and is qualitatively identical with hypermotility. The former is of myogenic origin [5] and of the nature of gastrospasm and the latter rises from irritation from within and from without the stomach as well.

Of the three physiologic portions of the stomach: the canalis gastricus, the saccular fundus, and the active pylorus, the pylorus, comprising the greater part of the organ that appears horizontally at laparotomy, is principally concerned in hypermotility. Fright stirs up very active peristalsis; so do appendicitis, duodenal ulcer, gall-bladder disease and lesions of the stomach itself: ulcer and cancer. Graham [6] writes that "bloating and pressure are more common in gastric than in duodenal ulcer," while in gall-stones "the gas present intensifies the distress and belching gives short relief." In these conditions, the irritation may be so intense as to convert hyperperistalsis into gastrospasm with retention instead of early emptying as the clinical manifestation. These phenomena account for the pain which Carlson [7] has associated with the gastric contractions and also for the abdominal distention.

Experiment II.—Fasting stomach corresponding to stomach of patient "prepared" for operation. Stomach powerfully contractile, with loud pyloric soufflé and of three cycle type.

(1) Index finger extended beneath lower angle of wound over parietal peritoneum as though about to raise the angle of wound for inspection. Result: Dilation of stomach, with absence of contractions for a few seconds, normal prostalsis and pylorospasm.

(2) Cæcum (appendix) clamped and released. Result: Dilation of stomach, with absence of contractions for three min., normal prostalsis and pylorospasm, slight irregularity in time and force.

(3) Gall-bladder clamped and released. Result: Dilation of stomach, with absence of peristalsis for three min., prostalsis and pylorospasm, increased irregularly in rate and increased force.

(4) Stomach at lesser curvature of pyloric region clamped and released. Result: Dilation and no contraction for a few seconds; strong retrostalsis beginning at pylorus

and progressing orderly to pylorofundic junction where the contractions disappear. (In the voluntary animal this would probably be accompanied by vomiting. This reversed peristalsis is therefore to be regarded as purposeful: as an effort to remove the irritation through the mouth.)

Conlusion.—Appendix and gall-bladder diseases are associated with hypermotility, including pylorospasm. Pyloric disease gives rise to reversed peristalsis.

From the above experiment it appears that relaxation and contraction of the involuntary muscle are balanced against each other very much as they are in voluntary muscle. Peritoneal traumata appear to cause cessation of the stomach's contractions and stimuli from the intestinal tract seem to start the contractions up again. There are doubtless innumerable extraneous causes of gastric hypermotility, and these experiments are significant in that they depict as possibilities certain common surgical findings in the human abdomen.

Similarly in three out of five animals trauma to the gall-bladder was followed by retrostalsis in the stomach and in the remaining two by forcible prostalsis or hyperperistalsis. These findings again correspond with the vomiting and epigastric cramp of gall-bladder disease. Clamping of the ureter is more difficult and necessitates a greater amount of peritoneal trauma which, in turn, is followed by a longer atonic gastric phase and the stomach contractions, when they do appear, are diminished normal (two experiments). Clamping of the pancreatic duct has been followed in one case by intense stomach cramp. Disturbances in the stomach and duodenum, due to diseased foci in other organs, differ from disturbances following localized lesions in the stomach and duodenum in this respect: that in the former instance there is general hypermotility, pylorospasm, or duodenospasm and in the latter there may be hypermotility but there is more likely to be localized gastrospasm or duodenospasm. In both types of stomachs and duodeni, there may be hypertonicity and hyperperistalsis, although in a few instances there are hypotonicity and diminished or absent peristalsis, but segmental spasm or the incisura is particularly characteristic of the localized lesion.

In subacute and chronic conditions the duration of the exciting cause: appendix, gall-bladder, or duodenal ulcer, implies that so long as the stomach remains anatomically normal it must repeatedly manifest hypermotility and pylorospasm. Röntgenographic evidences of hyperperistaltic stomachs in these cases as well as occasional accidental inspections of hypermotile stomachs in the operative room support this view. Indeed, it is quite generally agreed that the rule in individuals with chronic appendicitis is not only a hypermotile but a hyperfunctionating stomach inasmuch as hyperacidity is often associated with hypermotility.

Gastrospasm includes spasms of any part or of the whole of the organ. There may be spasmodic contractions of the cardiac or pyloric sphincters, segmental contractions appearing as incisuras, diffuse contractions of the pyloric ends, or total gastrospasm. Tetanic contractions of the

sphincters and the "incisuras" are, in surgical cases at least, often indications of local lesions, while diffuse and total spasms are probably qualitatively the same as hypermotility in most cases.

Cardiospasm is probably protective and occurs when the stomach's condition is unfit to receive food. This would correspond with Cannon's findings for the small gut in the presence of caudal obstruction. It follows that local irritation plays an etiological part in the surgical spasm of the cardia. This relationship was illustrated in a personal experience with cardiospasm which was associated with a pin imbedded in the parietal peritoneum and upper left abdominal rectus muscle sheath and which was relieved by the removal of that pin, and also in the suggestive case of Carman [8] and Miller in which duodenal ulcer was found two years after securing partial relief of the spasm by forcible dilation. It is possible that irritation from other parts of the abdomen may give rise to cardiospasm. This is supported by the anatomical researches of Keith [9] on the nodal significance of the cardia, by the heightened irritability described for the cardia by Alvarez,[10] and by the frequency of cardiospasm in high-strung nervous individuals.

Many writers contend the absence of peristalsis follows pathologic conditions of the ileocolic region in support of the so-called ileopyloric reflex. White [11] found that the motor effects of the stomach vary with the degrees of cæcal irritation, that these effects may be reversed peristalsis, pylorospasm, and hypermotility to no effects at all. This agrees with personal studies on the two ends of the small gut in which it appeared that the contractility of the duodenum varies with the end-resistance or obstructive irritation of the ileum.[12] The most frequent failure in motility, clinically met with, is that associated with the fatigue or atrophy of gastroptosis or, in other words, in those individuals of lowered general resistance who often have diminished gastric tone. Dilation follows prolonged pyloric stenosis. Personal experiments herein reported and to be published in a subsequent paper have not found splanchnic inhibition to be vitally concerned in gastric dilation, but they have shown a fairly constant cessation of the gastric contractile waves and gastric relaxation after rubbing of the parietal peritoneum or handling of the viscera which does suggest some form of nervous arc over which inhibiting impulses may travel. Furthermore, it appears that there is a fair constancy in the promptness of dilation succeeding traumata, in the duration of the dilation, and in the tendency of the stomach to remain dilated as the traumata are repeated or prolonged. It is extremely probable that the post-operative dilation of the stomach and that ileus are of this nature.

The phenomenon of reversed peristalsis is a part of normal physiology and when carried to excess is observed pathologically in thin-walled abdomens with pyloric stenosis and dilated stomachs. It may be confined to the pyloric end of the stomach and may continue while regu-

lar prostaltic waves are seen coming from the cardia; or retrostaltic waves from pylorus to cardia may occur alone. The protective function of anastalsis is manifested in the vomiting of acute toxæmias and obstructions.

Summary.—Atmospheric air serves as a basis for stomach gas. Gastric air tends to preserve normal intragastric tension at which the stomach contracts most effectually but above and below which the contractions fall off. Spontaneous rupture of the normal stomach is probably unknown. In dilated stomach the gas accumulates in abnormal amounts and correspondingly influences gastric peristalsis. The cause of chronically disturbed stomachs may lie in diseased appendices, gall-bladders, duodeni, or in other organs. Diseases of the stomach, appendix, gall-bladder, and duodenum may be associated with gastric hypermotility and pylorospasm. Contractions of the stomach and of the intestine occur, under certain conditions, in the open surgical abdomen and appear to be influenced by parietal and visceral traumata. Irritation of the parietal peritoneum appears to inhibit the stomach's motility; irritation of the abdominal organs by handling or instrumentation may stimulate or depress the motor functions of the stomach according to the degree of irritation.

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SEGMENTAL RESECTION FOR GASTRIC ULCER*

A PRELIMINARY REPORT BASED UPON CLINICAL AND EXPERIMENTAL STUDIES

BY GEORGE DAVID STEWART, M.D.
AND
WILLIAM HOWARD BARBER, M.D.
OF NEW YORK CITY
(From the Laboratories of Experimental Surgery, Physiology, and Röntgenology of the New York University)

THE problem has arisen in the treatment of gastric ulcer whether the removal of the ulcer-bearing site, which is commonly a saddle-shaped section from the lesser curvature of the pyloric region, or whether the resection of the ulcer-bearing segment is associated with the better post-operative motility. Given an excision operation that has been performed perfectly, technically, its success obviously depends upon the tonus and upon the contractions of the remaining stomach. Moynihan, Von Eiselsberg, and Mayo have called attention to the functional impairment following certain of these operations. W. J. Mayo, in his recent discussion of the surgery of ulcer at San Francisco, declared "the sleeve resection . . . gives an excellent permanent result. . . . Just why this operation, in which the corresponding part of the greater curvature is removed at the time the ulcer is excised, should leave the stomach with good motility while excision of the ulcer without removal of the segment of the greater curvature of the stomach leaves it with poor motility is an interesting conjecture." [1]

The radical operations for gastric ulcer have been

1. Simple excision with knife or cautery.
2. Simple excision with gastro-enterostomy added.
3. Simple excision with gastro-enterostomy and pyloric occlusion.
4. Pylorectomy and partial gastrectomy with some form of gastro-enterostomy.
5. Resection of the ulcer-bearing segment of the stomach ("sleeve" or segmental resection) with or without gastro-enterostomy.

The palliative measures have been the gastro-plastics and gastro-enterostomies alone or combined with the turning in or the strangulation of the ulcerous areas. Bloodgood, W. J. Mayo, Smithies and Ochsner have emphasized the tendency of gastric ulcer to become malignant. Patterson, of London, and others believe that comparatively few of the ulcers of the stomach develop into cancer. The present tendency of surgeons, however, is to treat ulcer as potential carcinoma and

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to add to whatever palliative measure has been adopted excision of the ulcer, thus lessening the possibilities of malignant degeneration.

Briefly, the indication for segmental gastrectomy is the large calloused ulceration. The technic consists in removing a segment of the stomach containing the lesion and in uniting terminally the divided ends. It calls for the removal of more tissues than that immediately involved in the ulcer but less usually than in pylorectomy. For the purposes of studying the motility of the stomach following the excision of the "cuff," the segmental method has been correlated with that of excision of the ulcerous area or "triangular" gastrectomy.

Several segmental resections have been performed.

Of the four cases presented, the first, second, and fourth have had complete gastric segments removed; the third, the ulceration, alone.

Case I.—J. H., admitted November 29, discharged December 31, 1915, sixty-three years of age, and born in United States of America. Occupation, watchman.

Family history irrelevant. Had rheumatism and venereal infections. Uses tobacco and alcohol. For the past two years attacks of vomiting and abdominal pain. Eructates gas and fluid. Has lost appetite and weight. Urine negative. Blood shows 5,696,000 reds with 80 per cent. hæmoglobin and 10,000 leucocytes with 79 per cent. polynuclears. Wassermann negative. Gastric analysis gives a total acidity of 85 and a free acidity of 54.5 with no blood, Boas-Oppler bacilli or sarcinæ.

Operation (December 4, 1915).—By Doctor Stewart. Removed a 2-inch segment of stomach bearing an ulcer of lesser curvature. Ends of completely divided stomach approximated by an inner chromic and an outer Pagenstecher suture. Cigarette drain left in the lesser sac of peritoneum. Uneventful recovery.

Case II.—N. M., admitted January 6, discharged February 4, 1916, twenty-nine years of age and born in Austria. Occupation, motorman.

Family history negative. Uses tobacco, habits and past otherwise negative. For the past 7 months attacks of nausea and epigastric burning or pain. Pain relieved by eating. Appetite good until just prior to entrance. Loss in weight slight (2–3 lbs.). Epigastric tenderness. Urine negative. Gastric analysis gives 54 c.c. of total and 6 c.c. of free acid, with no blood or lactic acid. Wassermann negative.

Operation.—By Doctor Stewart. Removed ulcer-bearing segment and performed gastro-gastrorrhaphy as in above case. Uneventful recovery.

Case III.—M. F. D., admitted November, discharged December 29, 1915, forty-six years of age, and born in United States of America, occupation, clergyman.

Family and past history irrelevant. For the past fifteen years eructation of burning fluid. For the past 3 months vomiting attacks. Has no abdominal pain. No masses, tenderness, or rigidity in abdomen. Urine negative. Blood shows 7800 leucocytes with 79 polynuclears. Gastric analysis gives a total acidity of .06 and a free acid of .08 with no blood or lactic acid. Wassermann negative.

Operation (December 13, 1916).—By Doctor Stewart. Ulcer of lesser curvature of stomach near œsophagus removed. Opening closed with inner chromic and outer Pagenstecher sutures. Two cigarette drains left in. Uneventful recovery.

CASE IV.—A. L., admitted March 28, discharged April 18, 1916, sixty-six years of age, and born in United States of America, occupation housewife.

Family and past history irrelevant. For the past 2 years nausea, losses in weight and in strength. Tender stomach mass distinctly palpable. Urine negative. Gastric analysis shows absence of free hydrochloric acid and no blood or lactic acid.

Operation (March 29, 1916).—By Doctor Barber. Adenocarcinoma of the body of the stomach resected and divided ends reunited by inner chromic and outer Pagenstecher. Uneventful recovery.†

The X-rays of all the above have been studied and are given below.

In attempting an experimental study of the motility of the stomach after segmental resection, it seemed wise, first, to review, briefly, the known muscle physiology of the normal stomach and, then, to compare the movements of the resected stomachs. These movements were observed directly before and after the removal of triangles and segments from the stomach walls, and indirectly through the tracings of changes in the intragastric pressure as well as through repeated X-ray findings of normal stomachs and of stomachs after resection.

It is generally agreed that (1) normal gastric prostalsis begins in the fundus in the vicinity of the cardia, that (2) the stomach is tonic and contracts peristaltically, that (3) this tone and these contractions are subject to certain influences, such as the general health of the individual, the contents of the stomach, the presence, or absence of irritable foci, the quality and the quantity of the blood supply, and stimuli from the vagus and splanchnic nerves, and that (4) normal prostaltic contractions which begin in the fundic portion terminate in the pyloric end of the stomach.

†This case is reported under Tumors of the Stomach, Ref. Handbook Med. Sciences, 1916, and is reported here because of its being a most recent segmental resection. Note the preservation of four-hour emptying two weeks postoperative.

The locus of origin of the individual contractions is not (to our knowledge) definitely established. From inspection of the dogs' stomachs under light ether narcosis, it appears to fall on a point, approximately, half-way down the descending arm of the lesser curvature. By different methods, Beaumont,[2] Brinton,[2] Becterew and Mislawski [3] placed the initial contractions at the cardia; Hofmeister and Schütz, "near the cardia;" and Auer [4] " near the œsophageal insertion." It is probable that the contraction actually starts at the cardia but does not become recognizable, macroscopically, until it involves the anterior face of the stomach a short distance distal to the cardiac sphincter.

From this fundic site, the wave is observed to sweep toward a corresponding point on the greater curvature and caudad in successive cross-sections. As it progresses, it keeps fairly transverse to the long axis of the stomach while the rate on the greater curvature is greater than on the lesser. The anthral sphincter (three to four fingers' breadth above the pylorus) contracts most forcibly: at least it shows the greatest indentation perpendicularly when viewed anteroposterially, and the greatest constriction when examined stereoscopically. Cole [5] has estimated the rate of this gastric cycle in man at 2.5 cm. per second and the time at 2 to 25 seconds. Auer mentions an " angular section of the preantrum " which the peristaltic wave " apparently skips in its course " to the sphincter antri. Brinton's theory of the three streams of the active stomach—namely, one along the greater curvature toward the pylorus, one along the lesser curvature in the same direction, and a reversed medial current—is given added significance by the observations of the return of solid particles from the antrum to the body of the stomach and by the contributions of Jefferson, [9] A. Herz, [10] and Moritz, [11] in respect to the existence of a gastric stream which following the lesser curvature empties at the pylorus.

The reciprocal dependence of the stomach upon the health of the individual is well known. The medical student, worn out at the end of his school year, often finds delay in his stomach which ordinarily empties itself perfectly. This constitutional factor enters into the force of the stomach movements and manifests itself under the same conditions of life in some instances by atony and in others by hypermotility.

The stomach's activity varies periodically according to phases of digestion. The time immediately following a meal divides itself into periods of forcible contractions alternating with intervals of relative quiescence. As the time increases after a meal, the contractile periods increase in length, from 12 min. for the relatively powerful contractions

to 30 min. for the strong ones. The intervals of rest vary from 5 min. for man (Carlson [6]) to 1½ to 2½ hours for the dog (Boldireff [7]). Not only do the contractions of the oncoming activity phases increase in intensity, that is in amplitude and in frequency, but the terminal ones may end in tetanus. Carlson has drawn attention to a continuous rhythm of 20 sec. duration which he believes to spring from the pyloric musculature and to be always present. Both the 20 sec. rhythm and the more forcible stomach contractions disappear with health. According to Alvermann, [8] Rossbach and van Braam-Houckgeest denied that the empty stomach possessed characteristic movements but Hofmeister-Schütz, Moritz, and J. R. Ewald maintain that the same movements take place, only slower and fewer.

A common example of an irritable focus is the appendix in appendicular gastralgia. The stomach is the spokesman for many diseases located elsewhere, more or less remotely, in the alimentary canal. For a given period of health, in response to these stimuli, the stomach changes in the tone of the cardia which may become a cardiospasm, in the tone of the pylorus which may become a pylorospasm, possibly in the tone of the body of the organ which may be a true gastrospasm, and in the tone of the sphincters and the body, combined, which may be a true gastric tetany.

The quality of the blood, obviously, to some degree characterizes the stomach's activity. Carbon dioxogen may be an essential factor in stomach tonus. When increased in amount, it possibly may account for some of the instances of inexplicable acute dilatation of the stomach. The influence of asphyxia upon the gastric tonus is pointed out by Morat [12] in 1880, by Battelli [13] in 1896, and, probably, again, by the following experiment:

> An apparently normal dog is induced to swallow a rubber bag and tubing. The animal is put under light ether. The tubing is connected up with a tambour and chloroform manometer and through these with a kymograph. (The apparatus is similar, in principle, with that used by Morat in 1882, by Battelli in 1896, and Carlson at the present time). The contractions observed, under these conditions, are represented in tracings 3, 4, and 5. Note that decreased oxidation or asphyxiation is associated with intermittent contractions of short duration as compared with those of the normally aërated animal.

The influence of the extraneous nerves upon the automatic activity of the stomach has been demonstrated by Bayliss, Schütz, Unger, and others. Bayliss's [14] illustration of smooth muscle tonus by means of the " catch " mechanism is particularly suggestive.

Because of the relations of the vessels and nerves to the stomach's activity, many of the research studies in which these structures have

been disturbed necessarily present sources of error. That many of the involuntary activities do persist for a limited time in tissues removed from the body is well known, but that such manifestations are normal remains to be proved. In the following observations, it will be found that motor activities from the individual under mild ether corresponded fairly well with the kymographic tracings from the voluntary animal with the intragastric bag, and with the X-ray findings. The clinical studies compare favorably with these experimental data.

The dogs, times of operation, the operative proceedings, and the subsequent histories are tabulated in Table I. The " subsequent report "

TABLE I

Dog No.	Date of operation	Operation and operative observations	After-history
58	No record	Segmental resection; duodenostomy	No methylene blue from duodenal stoma 2 hr. 45 min.
77	January 13, 1916	Triangular resection	Traced 41 days later.
78	January 13, 1916	Resection of neuromuscular triangle	Traced 41 days later.
92	January 19, 1916	Triangular resection	Records incomplete.
93	January 19, 1916	Triangular resection	Etherized for morphological study; stomach *dilated*.
101	January 27, 1916	Resection of neuromuscular segment	Died 14 days later; intragastric hemorrhage; size of stomach *normal*.
103	January 27, 1916	Resection of neuromuscular segment	Died 15 days later; nephritis; stomach *contracted*.
115	February 3, 1916	Resection of neuromuscular segment	Died 37 days later; pneumonia; stomach *contracted*.
114	February 3, 1916	Segmental resection and fascial transplant	Traced 46 days later; X-rayed 41 and 42 days later.
127	February 10, 1916	Segmental resection; rate of prostaltic wave 20 sec. for 10.9 cm. or 1.83 cm. for 1 sec.	Traced 46 days later.
128	February 10, 1916	Segmental resection; time of prostaltic wave 21.7 sec.	Died 40 days later of pneumonia; stomach *moderately dilated*.
151	February 24, 1916	Segmental resection; time of prostaltic wave 11.4 sec. for 6.25 cm. or 1.8 cm. for 1 sec.	Traced 23 days later; X-rayed 21 and 22 days later.
152	February 24, 1916	Triangular resection; time of prostaltic wave 8.9 sec. for 2.5 cm. or 5/18 cm. for 1 sec.	Traced 25 days later; X-rayed 20 and 21 days later.
184	March 16, 1916	Triangular resection; time of prostaltic wave 14.7 sec.	Traced 30 days later.
206	March 30, 1916	Segmental resection	Died 27 days later; pneumonia; stomach *slightly dilated*.
233	April 13, 1916	Segmental resection	Traced 4 days later; 15 days later reported in good condition.

SUBSEQUENT REPORT BEARING UPON THE RELATION OF DILATATION OF THE STOMACH TO MECHANICAL CONSTRICTION AT THE SITE OF THE GASTRIC WOUND

Dog No.	Autopsy findings on April 20, 1916	Wave counts during stage of analgesia
114S	Size of stomach normal; size of resected portion admits two fingers	Cycles of av. 30.9 sec. duration.
151S	Stomach moderately dilated; resected portion admits one finger	Cycles of av. 20 sec. duration.
78T	Stomach markedly dilated; resected portion admits one fingertip	Died, apparently of malnutrition.
152T	Stomach moderately dilated; resected part admits two fingers	Died, apparently of malnutrition and of confinement.
184T	Stomach moderately dilated; resected part admits one finger	Cycles of av. 21.3 sec. duration.

S refers to segmentally resected dogs; T, to those with triangles removed. The animals do not do well under conditions of confinement within doors. For respective lengths of post-operative life, compare above chart.

reveals what mechanical obstruction, if present, were found in two segmentally and three triangularly resected dogs.

From this series, it appears that ten animals were examined post-mortem after two weeks to over two months of postoperative life. Of these, three were triangularly and seven segmentally resected dogs. The stomachs of the former were noted as "moderately" dilated in two and "markedly" in one; the stomachs of the latter as "normal" or "contracted" in four, "slightly" dilated in one, and "moderately" dilated in two. Furthermore (and this comparison is not to be given much importance because of the limited number of observations), the times of the prostaltic waves immediately following triangular gastrectomies were 8.9 sec. and 14.7 sec., respectively, and the rate (in one) $^{5}/_{18}$ cm. per sec.; after segmental gastrectomies, the times were 21.7 sec. and 11.4 sec., respectively, and the mean rate (in two) 1.8 cm. per sec. If these findings, taken in themselves, have any significance they represent the segmentally resected dog's stomach as the more motile during life and the more normal after death. The intercurrent affections are to be considered as contributing causes or more properly end-results of mortality in the above instances.

During the brief period of observation (immediately after anastomosis of the stomach ends and before closure of the abdomen) the waves seemed slower, shorter, and certainly less distinct in the animals with the triangles resected from the lesser curvature of the pylorus, and more rapid, more forcible, and longer in those with complete cuffs removed from the region of the pyloric incisura. In the former, the contractile wave was not recognizable until the region of the greatest contraction was reached, but in the latter the wave could be first seen at the midpoint on the descending arm of the lesser curvature. In both, the wave

was not traceable beyond the gastric wound and the pyloric end remained relaxed as well as amotile.

TABLE II

SHOWING RESULTS OF TRACINGS OF INTRAGASTRIC PRESSURE TECHNIC SIMILAR TO CARLSON'S

Dog No.	Time after eating	Forcible contraction	Continuous contraction and duration	Tonus changes
77T	1 hr.	Absent	Weak and 20–40 sec.	None observed.
78T	2½ hr.	Absent	Weak and 20–50 sec.	Present.
114S	20 min.	Present	10–20 sec.	Present.
127S	1 hr.	Present	Absent	None observed.
151S	2 hr. 20 min.	Present	10–20 sec.	Present.
152T	20 min.	Absent	15 sec.	None observed.
184T	25 min.	Absent	10–20 sec. and weak	None observed.
206S	(See Table I)			
233S	50 min.	Present	10–20 sec.	Present.

In Table No. 2 presenting the deductions from the tracings of eight dogs, each of the animals recorded was taken from a similar environment, fed a similar meal, and traced from 20 min. to 2 hr. 30 min. thereafter for periods ranging from 30 min. to 4 hr. The record, therefore, simply denotes what the stomach is doing with the bread and water meal for the short interval studied. It is seen that under these conditions, the animals with segments removed show forcible contractions and tonus changes and that the dogs with triangles resected generally do not. Both, however, give evidence of continuous rhythm. Under the conditions of laparotomy, the dog's stomach was observed to contract continuously (as pointed out above), presenting, in effect, a one- or two-cycle stomach. (Compare this picture with that of the normal dog with the bismuth-milk meal.)

It is evident that with an air-distended bag in the stomach contraction from any part of the gastric wall can influence the contained air—that is, the bag is not selective in its transmission of changes in intragastric pressure. The motility of the gastric segment aboral to the gastric wound is not differentiated. The tonic condition of the pyloric portion was noted at operation and its subsequent dynamic condition has been studied by the X-ray.

Röntgenographically, one normal and two pathological dogs and four pathological human cases have been reviewed. The findings are given below and explain themselves.

The normal dog (Fig. 5) shows a two-cycle stomach, a well-demarcated pyloric region, and a duodenal cap (dog No. 185). The stomach is practically free from bismuth (300 c.c. bismuth-milk emulsion) in

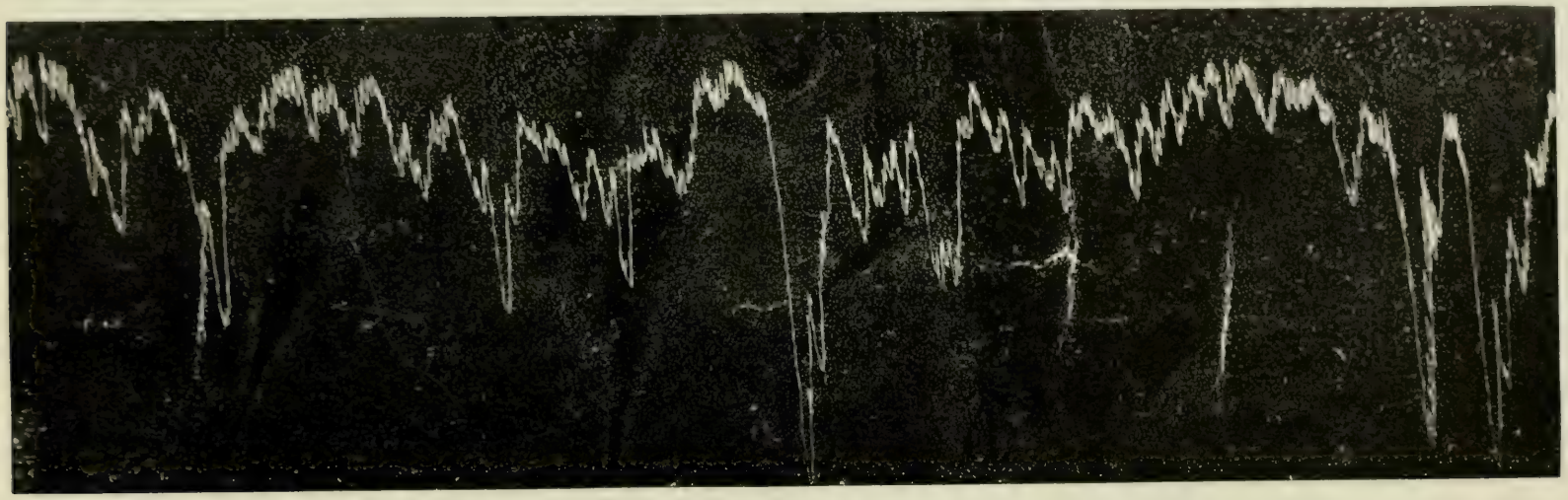

FIG. 1.—April 17, 1916. Dog No. 233 S. Traced 50 min. p.c. for one-half hour (portion of tracing).

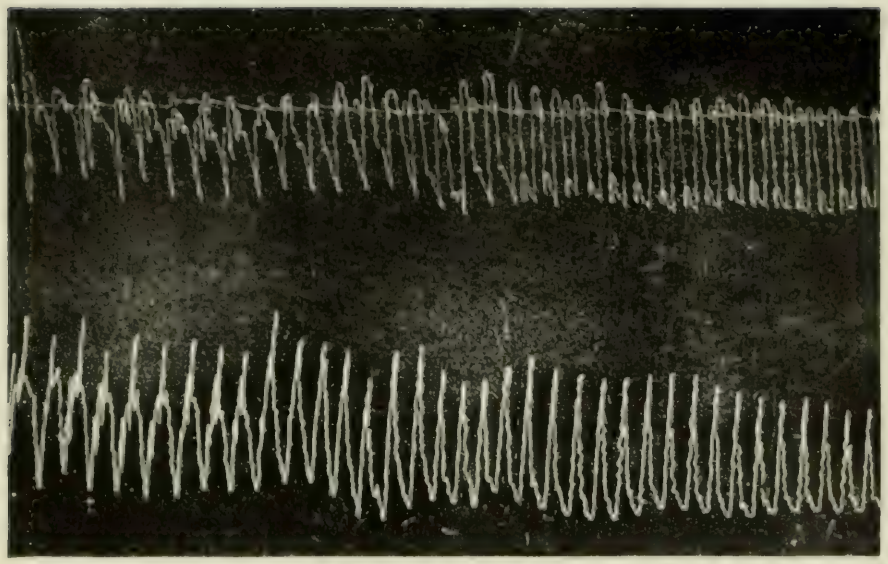

FIG. 2.—Normal dog, (1) under ether, (2) breathing, (3) with abdomen closed. Note continuous contractions.

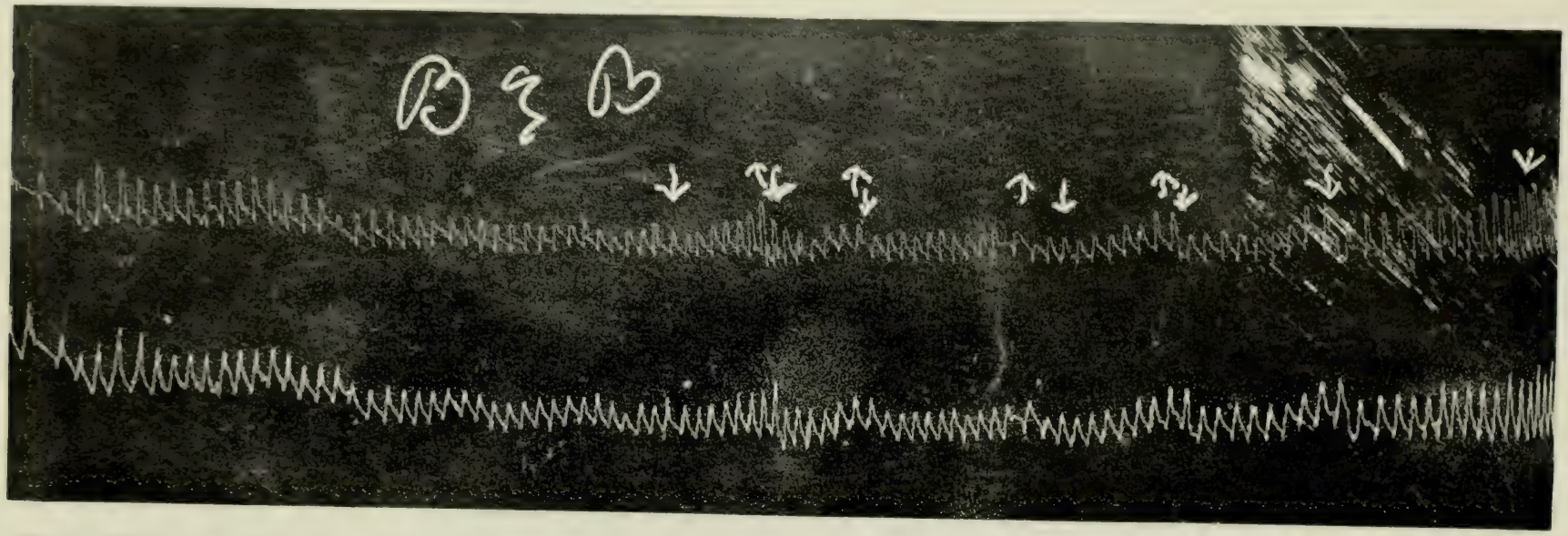

FIG. 3.—February 21, 1916. Normal dog, (1) under ether, (2) breathing, (3) with abdomen opened. Arrows indicate appearance and disappearance of gastric waves. Note continuous contractions. (Tambour above; chloroform manometer below.)

Fig. 4.—February 21, 1916. Normal dog under ether, apneic, with abdomen opened. Note incontinuous contractions of average ten seconds, with rest intervals of ten to fifty seconds duration, respectively. (Tambour tracing above, chloroform below.)

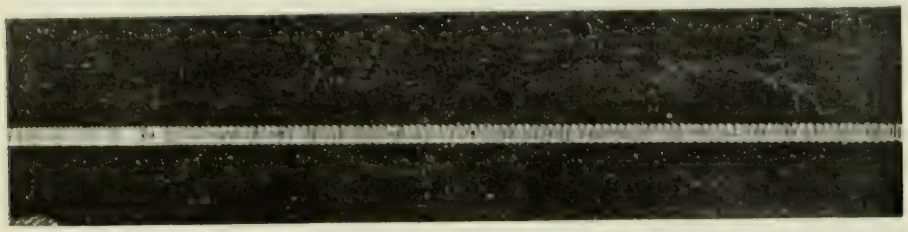

Fig. 5.


142— 2 HRS 51 MIN
TRIANGULAR
GASTRECTOMY

Fig. 6.


JEJUNUM
151— 2 HRS 41 MIN
SEGMENTAL
GASTRECTOMY

Fig. 7.

Fig. 8.—Case III.

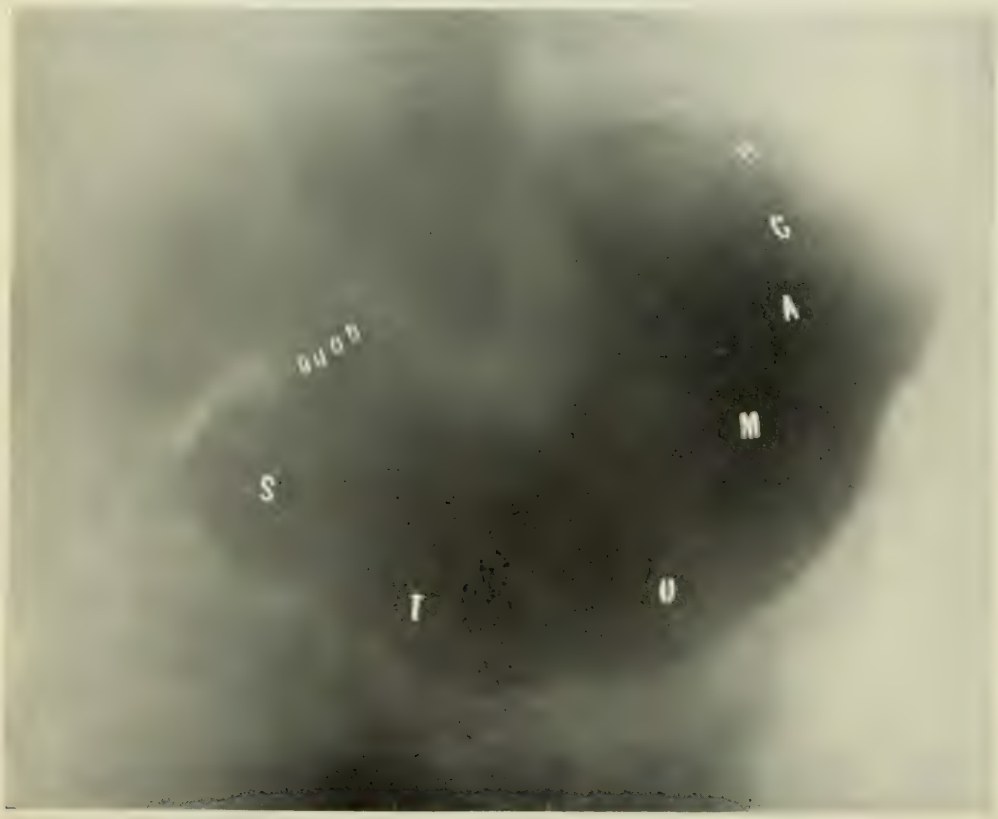

Fig. 9.—Case III.

FIG. 10.—Case IV.

FIG. 11.—Case IV.

3 hours and 20 minutes and the alimentary tract in (less than) 25 hours.

The dog with the triangle removed (152) (Fig. 6) shows a dilated stomach with no duodenal cap and a retention of most of the bismuth in 2 hr. 51 min. The column has reached the colon in 23 hr. 19 min. The segmentally resected animal (151) (Fig. 7) gives a pyloric region less distinctly outlined but a stomach, not as dilated, which empties 50 per cent. in 2 hr. 41 min. The bismuth is in the colon in 23 hr. 15 min. Dog No. 114, in which a segment was removed and the ends were held apart with a fascial transplant, throws a stomach shadow similar to that of the segmentally resected animal (151). All these three pathologic stomachs show on at least one of the exposures a two-cycle stage, similar to, but less distinctly than, the normal stomach (No. 185).

Case I, before operation, shows evidence of ulcer of the lesser curvature and a six-hour residue; after segmental resection, a pyloric end indistinctly filled out and a six-hour retention. Similarly, Case II, before segmental removal, gives indications of ulcer and a six-hour retention, and after, a forcible stomach with an undescribed pyloric end and a six-hour delay. Case III (Figs. 8 and 9) has an ulcer and a six-hour delay before, and a twenty-four hour retention (Doctor Le Wald's Report) after *triangular* gastrectomy. Case IV (Figs. 10 and 11) is well represented in the accompanying photographs. Note that the emptying time only two weeks after the removal of a large-sized segment from the pyloric end and body of the stomach remains the same as before operation, approximately four hours. (X-ray Report.)

This is a preliminary report upon a very interesting subject. The conclusions herein implied are tentative, and require further clinical and experimental study. The purpose has been to determine, if possible, which of the two methods, the resection of the ulcer-bearing segment or the removal of the ulcerous site for gastric ulcer leaves the stomach with the better postoperative motility. W. J. Mayo's report or implication that the " sleeve " resection is followed by good motility is borne out by the present study, certainly, in so far as the proximal segment is concerned, and apparently in respect to the distal one (compare emptying times of the human stomachs, notably Case IV, and of the dogs' stomachs). All the segmentally-resected stomachs have not emptied quite as effectively as normal stomachs but somewhat more satisfactorily than " triangularly " resected ones (Doctor Le Wald's Report on Case III and on Dog 152), as we hope to show more effectively in a subsequent report. This difference in the emptying times may be due in part to the mechanical relations incidental to the gastrectomies (see Table No.

1, Subsequent Report) themselves, but more probably (observations during experimental operations and postoperative tracings) due, in greater part, to the fundamental disturbances in the neuro-muscular motor mechanisms of the stomachs.

The authors desire to thank Prof. Holmes Jackson, of the Department of Physiology, for constructive criticism in the preparation of this article.

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ANNULAR SEGMENTAL GASTRECTOMY*

BY W. HOWARD BARBER, M.D.
OF NEW YORK
(From the Laboratory of Experimental Surgery, New York Univ. and Bel. Med. College and from the Polyclinic Hospital)

IN selected cases, the removal of a segment from the stomach appears to leave the organ with as efficient motor power as can be secured by any other resection of a corresponding amount of stomach tissue. In a previous communication, it appeared the stomach's emptying capacity following segmental gastrectomy was not equal to that of a normal stomach but greater than that of a stomach with a saddle-shaped piece removed from the lesser curvature. No explanation was offered for the stomach's respective behaviors after these resections. The following opinion was expressed: "This difference in the emptying times may be due in part to the mechanical relations incidental to the gastrectomies themselves, but more probably due in greater part to the fundamental disturbances in the neuromuscular motor mechanisms of the stomach." This has been taken as a working hypothesis for further experimental and clinical study which forms the basis of this paper.

1. *The Neuromuscular Motor Mechanism.*—The intrinsic nervous connections of the stomach are complicated and defy identification. It is fully realized that the vagi, themselves, are not pure cerebrospinal nerves but systems of central and sympathetic fibres to which are added other communications before and after their passage into the walls of the stomach. Other nerve groupings, styled the sympathetic nerves, obviously may not be purely autonomic for a similar reason but, on the other hand, may contain vagus elements. The constancy of any fixed proportion of central or of autonomic fibres in either extraneous nerve grouping is not and, so far as is known, cannot be determined; hence the futility of predicating gastric symptoms and signs to the impairment of either vagus or sympathetic nerve. In the accompanying drawing, the branches of the anterior vagus and the blood supply are represented in detail; if to the nerves indicated are added the great meshwork of sympathetic fibres that everywhere imbed the several vascular branches, some idea of the complexity of the nervous connections is obtained.

It is not surprising that the terms "vagotonia" and "sympathicotonia" when applied to gastric symptom-complexes are unproductive as working diagnoses. It is similarly hazardous to ascribe very much significance to experiments based entirely upon divisions of these nerves.

Most of the reported experiments are the direct observations of the experimenters or are the inferences drawn from the observed phenomena. Braun and Seidel[1] cut the spinal cord and noted the incompacity of the

* Read before Ex-interne Soc., M. E. Hosp., April 26, 1917.

[1] Braun and Seidel: Mitteila d. Grenzgeb, d. Med. u. Chir., Bd. 17, S. 533.

stomach to expel gas; they severed the vagi and found the emptying power to be present or absent and emetics to be powerless. Friedenthal [2] recorded no diminution in assimilation, digestion, and other functions after division of both vagi and splanchnics. Langley [3] held that the intrinsic stomach apparatus reduced by one-half the stomach volume by forcible contractions. Magnus and others reported movements of circular and longitudinal muscle when left in contact with Auerbach's plexus. Unger [4] found acute dilatation followed the division of the vagi in the chest. Others have corroborated these workers or have applied themselves independently in correlated studies.

The technic has been modified since the last series of experiments were reported (ANNALS OF SURGERY, November, 1916, vol. lxiv, p. 527). There are so many advantages in an open laparotomy over the visualized stomach or in the intragastric bag method that it has been used almost exclusively in the following study of the gastric motility, reserving the latter two resources as controls on the former or for the purposes of securing permanent graphic records. The activity phases outlined in the earlier paper have been taken advantage of by feeding each subject preliminary to ceilotomy a comfortable amount of diluted meat extract. The effects of ether, morphia, and trauma have been studied especially in relation to the element of time which enters into all experiments and as far as possible have been controlled. Each experiment is carefully written up and preserved. For convenience, the respective numbers, only, will be mentioned hereafter. (The numbers apply to experimental animals represented in the accompanying chart, entitled, "Résumé of Experiments Upon the Dynamics of the Stomach.")

Vagotomy was performed in five animals (123, 126, 134, 144, 171). *Thoracic section of the vagi* in these animals was associated with *a more rapid, more superficial fundic wave and an independent forcible pro- and anastaltic pyloric wave.* From this observation, it might be inferred, subject to further experimental proof, that the vagi carry motor fibres to the fundus and the inhibitory motor fibres to the pyloric portion. (This finding [5] is not new but corroborative of those experimenters who have held similar functions for the gastric fibres of the vagus.) Attempts have been made to associate motor changes with the corresponding divisions of extraneous sympathetic nerves but without apparent success.

The intrinsic apparatus is intimately bound up with the blood and vessel system. It is obviously impossible to clamp, ligate, or divide any of these nerve fibres without at the same time equally interfering with the vessels, muscle, and supporting fascia of the stomach or without, in other words, performing stomach block experiments. Of this character

[2] Friedenthal: Arch. f. Anat. u. Physiol., 1904, S. 579.

[3] Langley: Proc. Physiol. Soc. Lond., 1911, xiii, xxiv.

[4] Unger: Vide Friedmann, Arch. f. Verdauungskrank Erganz, Bd. 17.

[5] See Howell, W. H.: Text-Book Physiology, p. 665, 1907.

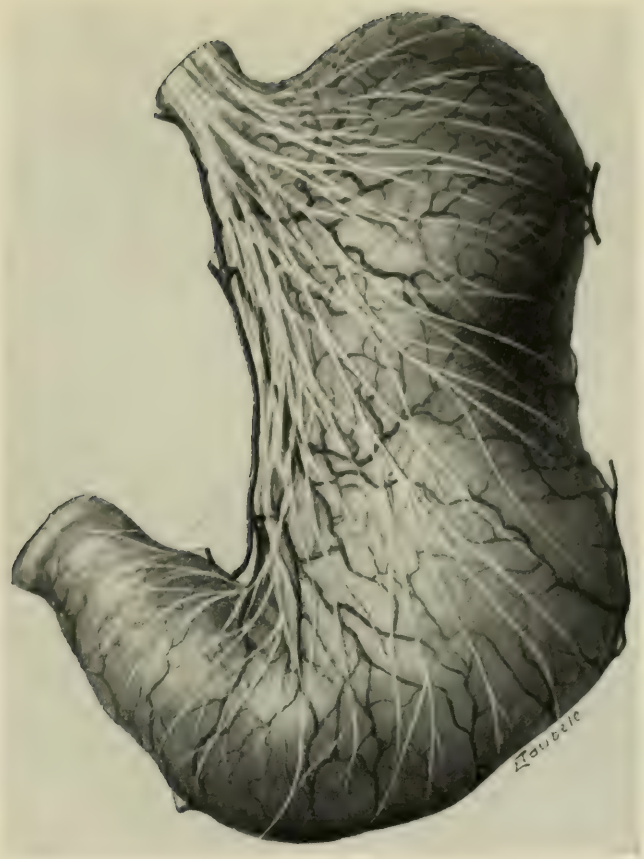

FIG. 1.—Drawing of human stomach from cast and from dissected specimen lent by Senior. Note blood supply and extensive ramifications of anterior vagus. Note, also, normal vertical position of organ.

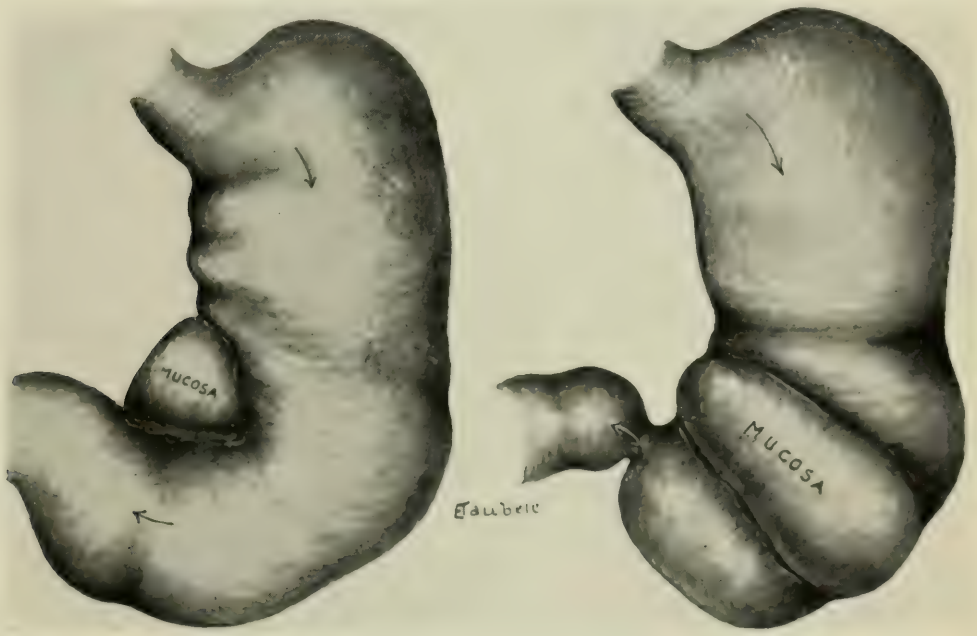

FIG. 2.—Experimental triangular gastrectomy indicating superficial peristaltic contractions of fundus and relatively amotile and atonic pyloric part.

FIG. 3.—Experimental annular segmental gastrectomy indicating a one-cycle, fairly tonic fundus and an independently motile and hypertonic pyloric part.

FIG. 4.—Persistent three-cycle type motility four weeks after operation. Compare with Fig. 3.

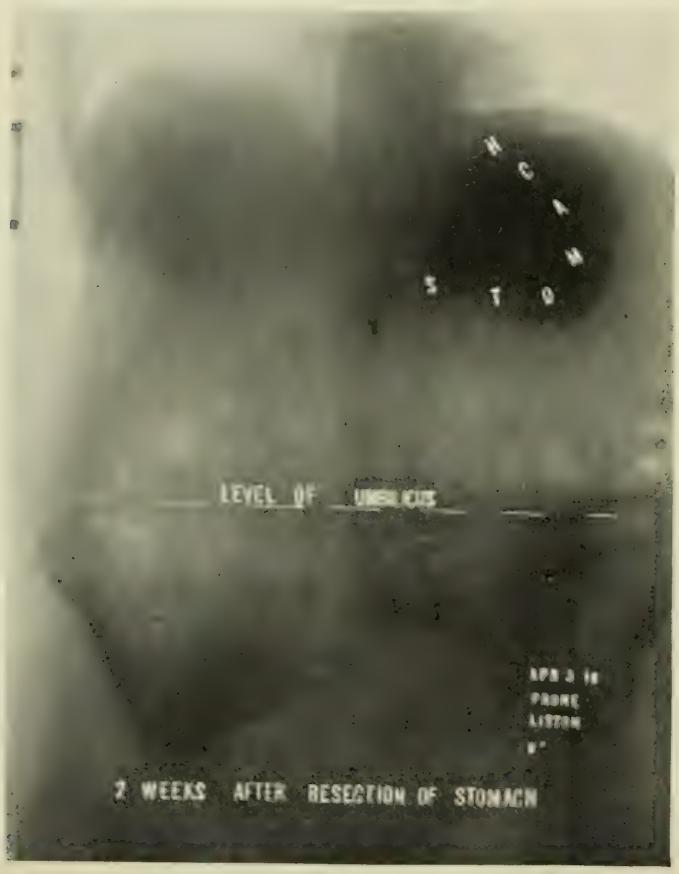

FIG. 5.—The more characteristic picture after annular segmental gastrectomy. Note pyloric part not demarcated. The exposure evidently coincides with a phase of pyloric hypermotility commonly observed experimentally.

are the following experiments. Incisions were carried astride of the lesser curvatures of the stomachs (in the pyloric regions of most animals or in the adjoining fundic portions of many others and, in one, in the vicinity of the cardia) half the perpendicular distances to the greater curvatures on both surfaces of the stomachs down upon or through the mucosa or saddle-shaped sections were removed; similarly, incisions were made completely about the gastric tube or annular segments were resected.

Under the conditions of incomplete blocking in seven animals (100, 101, 144, 149, 161, 165, 173) and making allowances for slight variation, it appears that *"triangular" gastrectomy was followed by more rapid, more superficial, fundic waves and more superficial, incomplete pyloric waves.* During the preliminary clamping and ligation there were stronger and slower waves (see experiments). The peristaltic contractions started high up on the lesser curvature close to (probably actually at) the cardia, traversed the stomach body, and disappeared in the proximal portions of the pyloric end of the stomach. The tonus of the fundus of the "triangularly" resected stomach appeared on the whole equal to or less than that of the unimpaired gastric fundus; the tonus of the pyloric portion, definitely less than that of the normal pyloric end.

In eleven animals (134, 100, 101, 101 six weeks later, 96, 96 six weeks later, 149, 165, 161, 144, 173) after making due allowance for slight variation, it appears that *"segmental" gastrectomy was followed by normal or stronger fundic waves and independent forcible pro- and anastaltic pyloric waves.* For the first few minutes to one hour following necessary manipulation, the waves in the fundic part were superficial. The tonus of the fundic part appeared equal to or greater than that of the normal stomach; that of the pyloric part, markedly greater.

When triangular resection or partial blocking of the caudad stomach is compared with segmental resection or complete blocking it will be seen that the latter method is associated with the more normally balanced fundus and the more actively efficient pyloric part. Furthermore, when the effects of thoracic vagotomy upon the pyloric portion are compared with those of segmental blocking, similarity again is found; in other words, the division of the two vagi in the thorax has the same influence upon the motility of the pyloric end of the stomach as severance of the neuromusculature at the pylorofundic junction. These observations agree with the inference offered above after vagotomy; namely, that the vagi carry inhibitory motor fibres to the pyloric portion of the stomach. It appears, therefore, that triangular gastrectomy allows some of these fibres to hold the intrinsic motor apparatus of the pyloric part in check but that segmental gastrectomy removes these inhibiting fibres. In respect to the fundic portions, it will be noted that the body of the stomach is reduced in tone and force of contraction after incomplete blocking and after thoracic vagus section but left with tone and contractions more resembling the normal experimental fundus after complete blocking. It is

possible that the centripetal fibres play an important rôle in these latter relationships, but, other than this suggestion, no explanation is attempted.

These experimental data correspond with experience in human segmental resection for gastric ulcer. A parallelism exists in comparative fluoroscopic studies; also, in human or in canine röntgenograms; and in observations upon resected brute animals (Cf. X-rays of human cases with Fig. 3). The fundi often require six hours for emptying; many stomach bodies have normal tone and good motility. The pyloric segments often do not appear upon the X-ray prints: this accords with the hypermotility or with the tetany of the distal portions observed in some of the experimental resections.

Case I.—Mr. J. S. V. referred to by Dr. J. Nolan, Aug. 17, 1916. Thirty-six years. Portuguese. Business man. Always constipated. Epigastric pain increasing in severity during past four years. Loss in weight. Rigidity and tenderness over upper right rectus. Le Wald reported probability of gastric ulcer. August 30, 1916, annular segmental gastrectomy for ulcer at lesser curvature in pyloric region. Pathological report: "Gastric ulcer highly suspicious of early malignant change." Four weeks post-operative residue less than half; condition very satisfactory. At present time reports himself back in business and entirely free from all gastric symptoms.

Case II.—Miss M. McG., case of Dr. J. M. Lynch. Trained nurse. Twenty-eight years. U. S. A. Diarrhœa since July, 1916. Epigastric pain five to six hours after eating—began ten years ago. Loss in weight. X-ray showed "almost complete obstruction of the stomach." November 17, annular segmental gastrectomy for gastric ulcer. Pathological report: "Gastric ulcer." Six weeks post-operative the six hour residue was considerably less than the nine hour residue before operation. She reports herself well and comfortably working at her occupation.

Case III.—Mr. H. S. referred by Doctor Matusoff, April 25, 1917. Thirty-two years. Russian tailor. Constipation past five years. Epigastric pain, worst after eating, past two years. Loss in weight. Stomach dilated. Hobbs (May 7) reports "almost complete pyloric stenosis with resulting dilatation." May 9, 1917, pylorectomy. Pathological report: "Pyloric ulcer with no recognizable evidence of malignancy." No unfavorable post-operative gastric symptom.

A locus of initial pyloric motility has been observed particularly in those stomachs showing independent pyloric rhythm. This site includes the gastric segment making up the incisura angularis. Its most motile point appears to lie at the junction of the first large branch of the right gastric artery with the lesser curvature of the stomach. Further research is necessary to establish possible nodal significance for this centre. (For convenience this "centre" is hereafter spoken of as the "C-point.")

2. *The Mechanical Relations.*—According to the methods above described, the loss of tissue and the resulting scar are greater after seg-

mental than they are after triangular gastrectomy. Whatever applies to obstruction due to the presence of or to the contraction of the cicatrix should pertain more forcibly to the former method. From experience in pyloric occlusion, it appears that persistent total obstruction of the physiologic outlet of the stomach is a difficult process even when it is purposely attempted. However, were it possible, notwithstanding one's exertions to the contrary, to seriously obstruct the stomach in performing one of these gastrectomies, it obviously must depend upon the resulting scar tissue.

Stricture is said to follow entero-enterostomy of non-peritoneal covered intestine. In experiments completed by the author it appears that all such productive inflammation after intestinal wounds has a rather more definite relation to the vascular supply of the apposed edges. This idea evidently prompted the "elbow" operation and other similar contrivances. The following experiment suggests this correlation of impaired blood supply and redundant gastric scar:

Dog No. 168 after morphine-ether and the usual preparation—Stomach divided in two transverse planes and closed by sutures; one, the aboral incision by a Connell suture, being careful to draw in the separate bites so as to *appose* the cut edges, the other, the oral, a Shoemaker stitch with two needles and oppositely drawn suture material *tautly pulled in to the point of strangulation of the edges* of the stomach wound. Two weeks later, this latter wound, although it involved the thinnest portion of the stomach sac was much more indurated and on cut section showed much more and firmer fibrous tissue.

Whatever be the cause of harmful scar tissue after gastrectomy, it ought to apply more to the stomach with the greater wound: segmental gastrectomy.

The mechanical removal of tissue from one curvature and not from the other, as in the triangular method, may result in a deformed stomach but it does not explain the deficiency of tone and the absence of contractile wave in those stomachs, above represented, in which the mucosa was left intact and the original dimensions of the stomachs preserved.

Résumé.—The removal of an annular segment from the stomach leaves the stomach with greater emptying power than the removal of a saddle-shaped section from the lesser curvature. This relationship is probably dependent upon the discontinuance in the neuromusculature and not upon the mechanical results of the respective operative procedures.

The writer wishes to thank Professor H. D. Senior of the Department of Anatomy, New York University and Bellevue Medical College, for his generous coöperation in the surgical anatomy. He is also indebted to Mr. A. Diem, the Laboratory technician, for his assistance with the experimental animals.

RÉSUMÉ OF EXPERIMENTS UPON THE DYNAMICS OF THE STOMACH

No. 311. Gastric wave begins at cardiac end of lesser curvature.

No. 206. Double clamping lesser and greater curvatures at corresponding points gives strong pyloric contractions; rate 1.3 cm. per sec.; recurrence, q. 21 sec.

No. 274. Cat's stomach of 2-3 cycle variety; recurrence of waves q. 20 sec.

Clamping half across from the lesser curvature gives more forcible pyloric waves; clamping all across gives blocking of pyloric waves.

No. 24. Dog's stomach of 2-3 cycle variety. Relation of motility to ether; waves decrease in height, force and rate but increase in regularity as ether coma approaches; waves increase in height, force, and rate becoming tetanic as the ether is withdrawn. Relation to "C-point": Clamping of C-point gives waves more rapid and increase in tone of fundus.

No. 25. Triangular gastrectomy gives weak waves in pylorus which become through waves from cardia.

No. 96. Segmental gastrectomy (Iwk. p. o.); Waves of 1 cm. per sec. in fundus; independent same time rhythm, pro- and anastaltic in pyloric part.

No. 100. Under morphine-ether waves normal recurrence time is q. 25-21 sec. After triangular gastrectomy recurrence time is 14 sec. After segmental gastrectomy independent rhythm of pyloric part.

No. 101. Under morphine-ether waves normal recurrence time is q. 25 sec. and rate 1.4 cm. per sec. After triangular gastrectomy recurrence is 14.75 sec., becoming more rapid, frequent, and superficial. After segmental gastrectomy (whether incision closed or not) tonic fundic part; atonic pyloric part with independent rhythm and waves infrequent, forcible, pro- and anastaltic.

No. 111. Vagi? Three branches anterior vagus below diaphragm clamped gives waves slower and more superficial (trauma necessarily considerable).

No. 117. Vagi? Anterior and posterior vagus above diaphragm cut gives waves of moderate force in pyloric part. CO_2? CO_2-blood gives increase in tone, localized contraction, total disappearance of contractions, general relaxation.

No. 123. Vagi? Both vagi cut above diaphragm gives waves forcible in pyloric part; relative amotility in fundic part or waves superficial, frequent, and difficult to follow. C-point, clamped, gives waves less forcible and more frequent in pyloric part.

No. 126. Vagi? Vagi cut above diaphragm gives increase in tone of whole stomach; increase in frequency of fundic waves; increase in force to all waves; does not alter rhythmicity of pyloric waves which are occasionally anastaltic.

No. 128. C-point, ligated, gives weak fundic waves disappearing at C-point, and traceable with difficulty beyond in pyloric part; decrease in tone.

No. 134. C-point, clamped, gives waves more forcible in fundus. Vagus ends divided at level of C-point gives in fundus waves rapid and superficial; in pyloric part, waves more forcible approaching tetany and independent rhythm. Vagi? Vagi above diaphragm cut gives waves weak in fundus.

No. 144. Triangular gastrectomy gives waves deep in fundus; superficial in pyloric part. Segmental gastrectomy gives waves of independent rhythm with pro- and anastalsis in pyloric part (whether wound in stomach closed or gaping). Splanchnics in chest cut gives waves no change. Vagi in chest cut gives waves shallow in fundus; no further change in pyloric part.

No. 149. Waves normally recur at 18 sec. intervals. Clamping of C-point gives waves of fundus more forcible but slower; waves of pyloric part more forcible and anastaltic. All waves decrease in tone 5 min. later. Suture? Pyloric waves forcible, anastaltic to suture; fundus waves forcible. Triangular gastrectomy gives fundic waves superficial to 1 cm. of incision; tone plus. Segmental gastrectomy gives fundus waves as after triangular gastrectomy; recurrence time 15 sec.; tonus same. Pyloric waves superficial pro- and anastaltic localized about distal cut edge; tonus same; recurrence q. 18 sec. Anastomosis does not alter these waves. Cutting of vagi in chest 95 min. after laparotomy gives no additional change.

No. 96. Segmental gastrectomy six weeks postoperative shows tonus of fundus normal; waves superficial and infrequent; tonus of pyloric part normal, waves forcible and tetanic. No mechanical obstruction.

No. 101. Segmental gastrectomy six weeks later gives tonus of fundus subnormal; motile pyloric part. No mechanical obstruction.

No. 161. Normal stomach gives "through" waves, two at a time, weak, at 22 sec. intervals, and continuous. Triangular gastrectomy gives waves same or stronger, at 20 sec. intervals in fundic part and after the first 2 to 5 min. weak and gradually disappearing in the pyloric part. Segmental gastrectomy gives waves more superficial in fundic part and absent in the atonic pyloric part.

No. 165. Normal stomach gives waves q. 15 sec. occasionally retroperistaltic, moderately forcible, continuous 2 cycle. Suture at C-point gives localized retroperistalsis beginning 1 cm. to right on lesser curvature and extending to the suture. Incomplete division of the stomach perpendicularly toward the greater curvature from C-point gives retroperistalsis from pylorus to cardia, waves q. 17 sec.; ½ hr. later normal prostaltic waves disappearing in the pyloric part. Complete division gives waves at first weak in fundus and pyloric part, 53 min. later waves forcible in both parts; q. 20 sec. in fundus and q. 40–60 sec., retro- and prostaltic in pyloric part.

No. 171. Waves (normal) in fundus strong and prostaltic; in pyloric part occasional retrostaltic waves intercepting strong prostaltic wave. Vagi divided in chest gives waves in fundus superficial and traceable into pyloric part, later to C-point, only; in pyloric part waves generally retrostaltic to fundic waves; later strong to C-point only (with an occasional prostaltic wave). Sutures placed at C-points serve only to enforce the above as does complete division of the stomach between these points.

No. 172. Triangular gastrectomy gives fundic waves superficial, strong in vicinity of incision, three at a time appearing on the lesser curvature; pyloric waves which are the prostaltic fundic waves disappearing early in the pyloric part; good pyloric tonus. Segmental gastrectomy gives fundic waves 1–2 at a time, weak or occasionally strong; pyloric waves independent pro- and anastaltic to within 1 cm. of incision.

No. 173. Triangular gastrectomy gives a moderately forcible 2–3 cycle fundus and a relatively atonic pyloric part with no waves barring the disappearing fundic waves in its proximal portion. Segmental gastrectomy gives a moderately forcible 1–2 cycle fundus with a moderately forcible pro- and anastaltic pyloric part. Site of gastrectomy as near to the cardia as possible.

"C-point" refers to site of special pyloric motility alluded to above.

By the "pyloric part" is meant that part of the stomach distal to the antral sphincter or incisura; the "fundic part," that proximal.

Note that the pyloric part behaves very much as a functional entity. It may be reasonable to speak of the surgical and of the anatomical pylorus, meaning by the former the whole pyloric portion invested by the thicker bundles of circular muscle fibres and of the anatomical pylorus as that commonly understood: namely, the termination of the pyloric end of the stomach canal indefinitely defined as from one-half to one inch in extent.

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GASTROENTEROSTOMY—THE STOMA AND THE EFFERENT LOOP.*

By W. HOWARD BARBER, M.D., New York.

The simple suturing of a loop of small intestine to the stomach without any particular regard for the location or direction of the stoma or for the disposition of the efferent loop may, under certain conditions, accomplish approximately normal gastric emptying. When the pylorospasm disappears, or after the gastric tonus has improved, the stoma may appear functionless. This "interval" functioning may be all that is desired; if it is, almost any gastric opening into the cephalad small gut should suffice. Occasionally the pathological changes are permanent or of increasing severity, so that continued stoma efficiency is required; the position of the stoma, the direction of the stoma, and the peristaltic type of the gastroenteric anastomosis will then be important considerations.

It is conceivable that many mucous erosions of the pyloric portion of the stomach and of the duodenum are of the former type. The accompanying pylorospasm protects the ulcer site and encourages, possibly by increased intragastric pressure, the passage of the stomach contents out of the new opening. Should there be much induration or retardative adhesions or malignancy under conditions that indicate gastroenterostomy, it is probable that a properly placed stoma joined to an isoperistaltic loop of proximal jejunum will, in the majority of instances, be associated with the greatest degree of postoperative comfort.

It is helpful to consider the stoma and loop from an anatomical as well as from the physiological point of view. Consider, especially, the following:

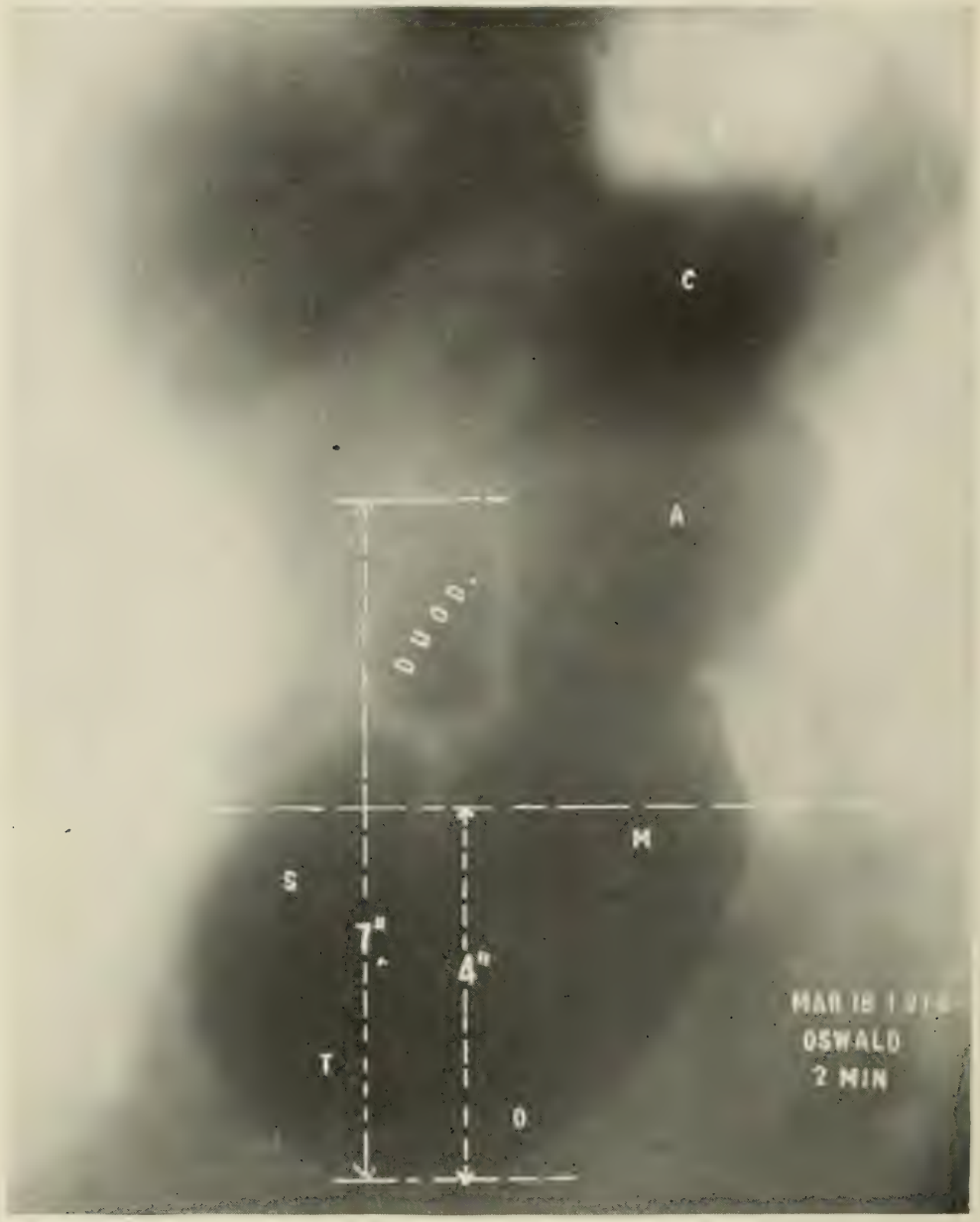
The ". . . . proper site for the gastric incision . . . is on a line with the longitudinal part of the lesser curvature, with its lower end at the bottom of the stomach (under the cardiac orifice)."[1] He finally advises that the efferent loop of the jejunum be directed form right to left.

"When the ulcer is at the pylorus or in the duodenum, I make the opening between the jejunum and the stomach, as near the pylorus as possible," and "three inches of the first part of the jejunum are temporarily fixed to the posterior wall by my catch forceps in such a direction that the proximal part of the intestinal loop points to the cardiac end and lesser curvature." Later, "I

*From the Department of Surgery, New York University and Bellevue Hospital Medical College.

now make the anastomosis from the lesser curvature to the greater across the pylorus, and turn the jejunum toward the left."[2]

The gastric stoma is made ". . . in line with the right margin of the esophagus, and it ends below at the lowest point of the greater curvature."[3] He further remarks that the opening in the



DILATATION OF STOMACH.

Fig. 1.—Dilated stomach, with symptoms covering two decades substantially unrelieved medically or by a surgical suspension, cured symptomatically by posterior gastroenterostomy with a transverse "pendant" stoma. Cf. similar experience recorded by Mayo-Robson in Surgery (Keen, W. W.), 1909, III, pp. 892, 947. This illustration is taken from a previous publication of the author in the Medical Record, May 1, 1915, p. 10.

stomach should be vertical and the efferent loop should be straight downward.

". . . In cases of marked stenosis or closure of the pylorus every method answers the purpose. . . . It is a good plan to make the opening in the stomach at right angles to the greater

curvature." The jejunum should be placed in the direction of the long axis of the stomach.

Observe that according to these opinions the ideal gastric stoma is vertical or perpendicular, that it is located in the distal fundic portion or as near the anatomical pylorus as possible, and that the efferent jejunal loop is directed straight downward—downward and to the left or downward and to the right. Obviously the direction of the loop naturally coincides with that of the gastric stoma. If the stoma is in line with the vertically descending arm of the lesser curvature, the jejunal loop will be directed straight downward; if the opening is obliquely downward and to the left, the loop takes the same direction; or if the line of the anastomosis is within the pyloric part and actually perpendicular to the greater curvature, the efferent loop must be directed downward and to the right. The disposition of the jejunal loop is a relatively unimportant one, being, as it appears, dependent on the position and direction of the stoma. Substantially, the proposition is, shall the gastric stoma be juxtapyloric or pendent and perpendicular, vertical, or directed from above downward and to the left.

Clinically, gastric function is difficult to study directly. Spontaneous cases have presented themselves after gastrostomies that lend themselves favorably to isolated observations. Fluoroscopically, some evidence is obtainable. In many respects, for surgical purposes at least, experimentation upon the mammalian stomach is most satisfactory. The animal is fed a beef bouillon and cracker meal, a hypodermic of morphine is given him, and from 15 to 30 minutes later he is slowly etherized by the drop method of induction. With the animal lightly under the general anesthetic, laparotomy is performed and the stomach's activity is directly observed for a period of from one to four hours. Similarly, in the course of human operations, one notices actively, often forcibly, contracting stomachs. Under these conditions peristaltic waves are seen which are apparently identical with those observed fluoroscopically or with the oscillations of intragastric pressure. They recur at 15 to 25-second intervals, are generally regular, forcible, and complete peristaltic waves. By keeping constant the anesthesia, instrumentation, and handling, it is possible to make one, two, or three openings in the stomach and to note the respective effects upon the gastric cycles. It is also possible to observe the effects of the peristaltic waves upon the stoma and the efferent jejunal loop.

Effect of the Stoma Upon the Gastric Wave.—From a limited number of experiments it appears that the gastric peristalsis continues, with slight interruption, after stomata have been placed in the proximal fundic, middle fundic, or in the pyloric portions of the stomach, or after all three openings have been made. Each wave approaches the immediate vicinity of the stoma, disappears,

and appears again close to the far side of the stoma-bearing area, whence it continues to the pylorus. This area of no contraction varies with the lateral extensions of the stoma; it is greater for the transverse than for the vertical opening. In other words, these stomata placed along the greater curvature of the stomach

Fig. 2.—Reproduction of cast of normal stomach and duodenum to show the normal relations of stomach, duodenum, and duodeno-jejunal flexure. Half normal size. Note extent of duodenal circumference, height of flexure from which jejunum swings horizontally to left, and compare with Fig. 3. This drawing was carefully made from a human casting in the possession of Prof. Senior, and is believed to represent accurately the normal relations of stomach, duodenum, and duodeno-jejunal flexure.

cause relative insufficiencies of the stomach wall, while the peristaltic activity of the stomach as a whole continues with about the same regularity, rate, and direction. The force of the prostaltic wave is impaired most with the transverse and least with

the vertical stoma. The stoma high on the greater curvature of the fundic portion appears to interfere least, the opening at the middle of the fundus more, and that in the pyloric antrum most with the force of the peristaltic wave. It appears true that the mid-fundic, transverse stoma gives a marked disturbance in the force of the wave and paralyzes a considerable portion of the gastric musculature, and that a pyloric, vertical opening impairs relatively less of the total or regional contractile power of the stomach.

Effect of the Wave Upon the Stoma.—The contents of the stomach are squeezed out of the stomach opening wherever it may be during forcible respirations and peristaltic contractions. The chyme appears to gravitate from the upper and middle fundic openings, and

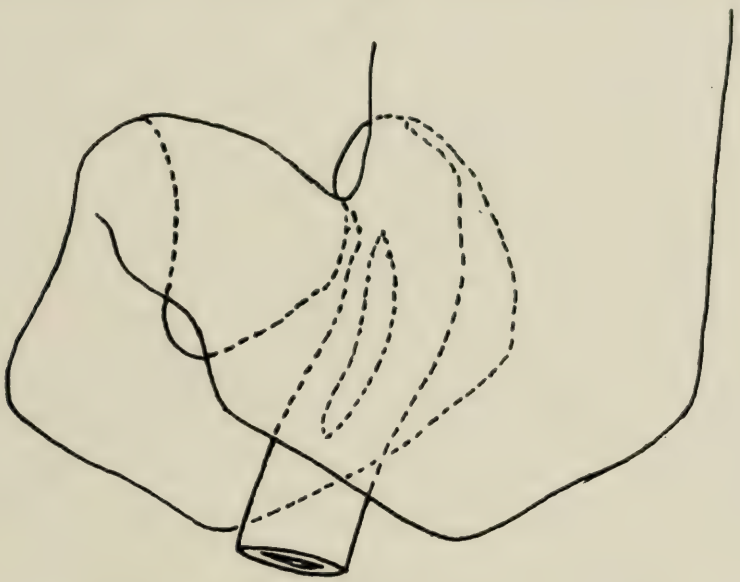


Fig. 3.—Diagrammatic representation of a gastroenterostomy with a perpendicular stoma and a downward-directed efferent jejunal loop. Adapted from human cast. Half normal size.

to be propelled from the pyloric and occasionally from the mid-fundic stomata.

Effect of the Wave Upon the Efferent Jejunal Loop.—It is observed that the direction of the ejecta from the pyloric opening of a stomach working under ideal conditions coincides with the direction of the stomach's drive—namely, from left to right. This applies particularly to vertical pyloric and occasionally to mid-fundic stomata. In one instance a proximal loop of duodenum was found choked with gastric contents following a pyloric exclusion and a heteroperistaltic anastomosis between the jejunum and the pyloric antrum. On this basis it is probable that some of the immediate untoward symptoms following gastroenterostomy are explainable. It seems reasonable to believe that a union of the small gut with the stomach that throws the efferent jejunal loop downward or downward and to the right, which is

a position that throws the gastric-emptying peristalsis in line with the jejunal-continuing peristalsis, will carry off the greatest amount of the chyme in the shortest time.

SCHEME OF EMPTYING FROM GASTRIC STOMATA OF NORMAL STOMACHS.

Vertical type of stoma—experiment No.	Located in		
	Proximal fundus	Mid. fundus	Pyloric part
176	plus	plus	plus plus
183	plus	plus	plus plus
193	?	plus	O
Horizontal type of stoma			
177	?	O	
182	plus	plus plus	plus plus plus
188	?	O	O
190	plus	plus	plus plus plus

"Plus" indicates the bulk of material and not the force of its ejection from the stomach. Drainage rather than emptying applies to the horizontal fundic stomata.

COMPARATIVE EMPTYING PERCENTAGES FROM STOMATA OF ARTIFICIALLY DILATED STOMACHS.

Experiment No.	Das. postoperative	Percentage emptying from	
170[5]	35	Antral stoma, 31	pylorus, 69
113[5]	30	"Pendant" stoma, 88	pylorus, 12

On the basis of the experimental data presented, and on its clinical application to date, the following recommendations are offered (providing the presence of ulcer, adhesions, or new growth positively indicate the performance of gastroenterostomy):

1. "For normal or hypertrophied stomachs, the nearer the artificial stoma coincides with the physiologic point of outlet, the greater is the efficiency of the stoma."[5] The stoma should be a perpendicular one.

2. For stomachs dilated beyond apparent hope of regeneration, the transverse, mid-fundic stoma seems most efficient.

3. For moderately dilated stomachs or stomachs in which an appreciable return of original tonus may be expected, a perpendicular antral stoma seems most efficient.

4. Whenever possible, the jejunum should be so chosen that the portion to be anastomosed falls naturally along the line of the proposed gastric opening. Excepting in atonic stomachs, in most instances the course of the efferent loop will be downward or downward and to the right.

Open the lesser sac and push the mesocolon off from the posterior surface of the pyloric part and toward the pyloric sphincter. In this manner the ascending and horizontal limbs of the duodenum with the superior mesenteric and midcolic vessels, are left dorsal and undisturbed. With little effort the antrum underlying the vertical arm of the lesser curvature is exposed. This normally measures two or more inches perpendicularly from the greater curvature to the junction of the vertical and horizontal divisions of the lesser border of the stomach. Such a line of incision opens the stomach terminally, making it possible to create a kind of termino-lateral union with the jejunum. The jejunal loop as near the duodeno-jejunal flexure as feasible is chosen; its efferent loop is thrown in the direction of the long axis of the stomach—straight downward or downward and to the right.

The horizontal position of the first part of the jejunum depicted under normal conditions in the accompanying drawing is, at any event, necessarily changed. In this instance, it is made a downward one. The pathologic physiology of this new gastroenteric relationship is represented in the above recorded observations.

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THE SIGNIFICANCE OF INCREASED DUODENAL DILATABILITY.*

BY W. HOWARD BARBER, M.D.,

NEW YORK.

THERE is a tendency to ascribe all duodenal dilatations to immediate constrictions, to obstructions which are frequently located at the duodenojejunal flexures. There are other factors, however, of duodenal dilatation or, more precisely, increased duodenal dilatability which are just as tangible, if not just as comprehensible, which are not resident in the duodenum, but in the terminal ileum.

Increased duodenal shadows have been observed röntgenographically in individuals found to have at operations pathologically involved caudad ileums. The ileocecal regions of these individuals are commonly caught in the adhesions which apparently represent the sequelæ of acute appendicitis. The appendix is normal, not often chronically inflamed, but the end of the small gut is partially obstructed. But after this appendix is removed and the neighboring bands restricting the ileum freed, not only do the gastric emptying and the duodenal clearance improve, but the dyspeptic symptoms often disappear at the same time. Clinically, therefore, these

*From the Laboratory of Experimental Surgery, New York University.

Colon immediately after removal, showing markedly dilated cecum and cephalad colon following incomplete obstruction of rectum.

postinflammatory bands interfere with the contractions and relaxations of the proximal as well as of the distal ends of the small gut.[1]

The question arises whether any causal relationship can be shown experimentally to exist between this form of incomplete ileac obstruction and apparent overdistensibility of the head of the duodenum.

An analogy, commonly known, is that habitual constipation gives rise, after a period of time, to increased dilatability of the cecum. Although such a cecum has been called "crepitant," large, or dilated, pathologically one is often at a loss to find anything structurally wrong with it. Furthermore, anyone may produce such a hypotonic cecum in normal dogs by tying gauze ligatures about the terminal colon so as to produce incomplete obstruction. When this obstructing band or the habitual constipation is removed, the tone of the head of the large gut improves. (See illustration.) It is logical on the same basis to expect similar disturbances with the beginning of the small intestine from inflammatory interference with the end of the ileum. To determine whether there is such an interrelation of the oral and aboral ends of the small gut, the conditions observed in humans were duplicated as far as possible in dogs. The results of these experiments have been published.[2] From this series it appeared that increased dilatability of the cephalad duodenum followed incomplete obstruction of the terminal ileum. Similar results have since been obtained on cats. (See the table.)

There appears, therefore, to be some underlying dynamic factor in increased ileac resistance that reduces the tone of the cephalad portion of the small intestine.

From these observations it seems logical, in the presence of a markedly increased duodenal shadow (as depicted by the *x*-ray during gastric emptying), to consider upon inferential grounds at least the possibility of a functionally obstructed terminal ileum.

TABLE SHOWING DEPENDENCE OF TONE OF CEPHALAD END OF SMALL GUT UPON CAUDAD END.

Animal No.	Duration of Obstruction, Days.	Dilatability of Duodenal Loop, c.c.	
		Before Ligating Colon.	After Ligating Colon.
Cat 338	14	2	2.5
Cat 339	4	1.5	2.9
Cat 344	6	1.7	2.15
Cat 324	3	3.33	3.8
	8	3.33	3.7

Another association developed during the same two series of animal experiments; namely, decreased dilatability or increased tone of the oral end of the small intestine and complete obstruction of the aboral end. When the distal ileum became closed by inflammatory reaction or by fecal accumulation, the size of the duodenum decreased. The decrease in the duodenum appeared in both the dog and cat series.

The time element requires especial emphasis. In the experiments the duration of the terminal ileac obstruction was four to nine days. Traumatizing by handling or scratching the terminal ileum produced no immediate change in the tone of the duodenum so far as could be ascertained. In the humans coming under our control the time factor is usually longer. It is illuminative, however, to see that,

dynamically, duodenal tone appears to be influenced by the tone of the terminal ileum.

In this light, the increased duodenal bismuth shadow does not exclusively indicate immediate obstruction, but possibly obstruction at some distal point, as in the terminal ileum.

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616 MADISON AVENUE.

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ON THE CO-ORDINATION OF THE TWO ENDS OF THE SMALL GUT. ITS SIGNIFICANCE IN GASTRO-INTESTINAL SURGERY.*

By W. Howard Barber, M. D., of New York,
Instructor in Surgery, New York University

It is quite generally admitted that ileac delay is associated with dilatation of the duodenum. Ileac delay is commonly due to some form of incomplete terminal ileac obstruction. In other words, incomplete obstruction is often associated clinically with dilatation of the duodenum. Experimentally,[1] it has been shown that partial occlusion of the distal end of the ileum is followed by increased duodenal dilatability. The significance of this relationship lies in the suggestive diagnostic value of enlarged duodenums.[2] If a roentgenogram records a duodenum of increased size, one might infer, on the basis of the above considerations, that the distal part of the small gut is involved in adhesions or otherwise obstructed so as to interfere with its emptying power.

The writers on 'intestinal stasis' have drawn attention to the causative significance of the ileocecal region upon dilatation of the duodenum.[3] Ochsner[4] begins with the inflammation of the appendix which, he says, reflexly closes the ileocecal sphincter, causes delay in the end-ileum, and contracts the 'duodenal sphincter,' and checks the normal progress of the food in the proximal 10 cm. of the duodenum. Lane[5] emphasizes the obstruction of the ileum by 'kinks' or by bands which mechanically retard the contents in the aboral ileum, cause the overfilled ileum to 'drag' on the duodeno-jejunal flexure, and in this way to produce 'stasis' and dilatation of the cephalad duodenum. Many *normal* appendices have undoubtedly been removed and their removal has relieved the patients' symptoms. It may be that an anatomically normal appendix may

*From the Laboratory of Experimental Surgery, New York University.

(possibly biochemically) close the ileocecal 'valve'; it seems more probable that the appendix, once the source of an active inflammation, has, in the healing process, so interfered with the normal relations of the ileocecum as virtually to effect an incomplete obstruction in the caudad ileum, and that the severing of such an appendix relieves these restraining bands. Furthermore, it must not be forgotten that the ganglionic relations of Auerbach's plexus are particularly rich in the duodenal loop and about the termination of the ileum in the cecocolon, the so-called 'loculus rotundus.'[6] With this in mind, it seems quite probable that stimuli arising in the terminal ganglia are transmitted to the proximal duodenal nerve cells and that this interchange is manifested by changes in the neuromuscular tone of the two ends of the small gut. Either an appendicitis or a fatigued end-ileum might, conceivably, furnish such stimuli.

When the delay in the terminal ileum is so marked as to amount to a complete tie-up of the ileac contents, the duodenal tone, during the first five days at least, increases. The same duodenum might, therefore, appear dilated at one examination and contracted at another. On the basis of such reasoning, a hypotonic or a hypertonic duodenum suggests a possible impairment of the end of the small intestine.

TABLE SHOWING THE INCREASE IN DUODENAL TONE FOLLOWING COMPLETE ILEAC OBSTRUCTION IN CATS.

Animal No.	Days of Obstruction	Dilatability of the Duodenum Before and After
336	3	3.5 c.cm. 1.66 c.cm.
337	3	2.5 c.cm. 2.0 c.cm.
327	5	21.5 c.cm. 7.0 c.cm.
329	4	3.33 c.cm. 2.0 c.cm.
330	4	3.8 c.cm. 1.75 c.cm.
331	4	3.0 c.cm. 2.87 c.cm.
335	3	8.0 c.cm. 1.9 c.cm.

Such an arrangement between the ends of a neuromuscular tube is not unique. Analogies are found in the two ends of the large intestine and between the two extremities of the ureter.

The difficulties in utilizing the above data in everyday practice are the comparative infrequency with which the duodenum is pho-

tographed in serial *x*-ray studies of the gastro-intestinal tract and the possibility of an abnormally large or small duodenal shadow being the index of a duodenum that is large or small as the result of some other disease process in the body. In the presence of other evidence of ileac delay, an atypical duodenal picture should increase the likelihood of terminal ileac obstruction.

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616 Madison Avenue.

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OBSTRUCTION OF THE APPENDIX.*

BY W. HOWARD BARBER, M.D.,

NEW YORK.

OBSTRUCTION may occur in any of the hollow tubes of the body and may produce appropriate symptoms. The blood-vessels have their thrombi, the ureters their urinary deposits, the bile passages their biliary concretions, and the cecal appendix its fecal accumulation.

Obviously, manifest obstruction does not depend solely upon the foreign body but in addition upon the neuromuscular drive of the appendical tube. In a measure, therefore, all obstruction is both dynamic or mechanical and adynamic or neuromuscular.

This relationship has been studied in respect to the ureter. One neuromuscular apparatus of each of several dogs' ureters was impaired by freeing the ureter from its retroperitoneal bed, stripping it of its vessels and nerves, and destroying the plexus in the adventitia of the ureter by rubbing it throughout with dry gauze. In each instance, the ureter was returned to its bed after care to protect it as far as possible from injurious adhesions. Seventy-

*From the Laboratory of Experimental Surgery, New York University, and from the Department of Colonic Surgery, Polyclinic Hospital, New York.

five per cent. of the animals showed hydronephrotic change (1913); the following year 83 1/3 per cent. of 12 animals similarly treated gave evidence of hydronephrotic or hydroureteric change. There was no discoverable complete obstruction in any of these ureters; the ureterovesical valves were tonic or relatively hypertonic. It seemed likely that the potential driving power of the ureter was exhausted against these valvular barriers so that, in effect, an adynamically obstructed or constipated ureter was produced.

At the same time similar studies were performed upon the small and upon the large intestine the results of which have been reported.

It is generally agreed that obstruction of the proximal end of the alimentary tube is more lethal than that of the distal end. It is also recognized that complete obstruction is far more disastrous to the animal than incomplete or unilateral occlusion. Draper, Whipple, Hartwell, and others have repeatedly emphasized the death-dealing power of closed duodenal loops. My experiments have found the dogs with closed duodenal loops to die within a few hours to seven days and the animals with closed colonic loops in several instances to live on for two to three months or more. That the semi-occluded and semi-obstructed intestinal loop may become a real source of danger is evidenced from a study of the oral colon in ileosigmoidostomy. This proximal portion enlarges in a proportion of cases and to the symptoms of toxemia are added the signs of mass. Experimentally, these animals have been found to live on about the same as those following colocolostomy and the leaving in of doubly occluded and doubly excluded intestinal loops. In some respects, the

appendix which outlasts its purposefulness is a semi-occluded and semiobstructed intestinal loop. Such an appendix is very liable to become a doubly occluded and a doubly excluded intestinal loop.

Apropos of the appendical life history, Cunningham (Textbook of Anatomy, 2d Ed. p. 1080) gives the proportion of the length of the appendix to the colon as 1:16 or 17 at birth and 1:19 or 20 in the adult. The cecal appendage undergoes partial or complete occlusion in 3 per cent. of all cases and in 50 per cent. of those over sixty years of age. Physiological atrophy beginning with middle life is the natural course of appendical development.

Should involution be delayed beyond the stage of functional usefulness of the organ, obviously, it becomes an abnormal appendix. Should physiological occlusion proceed in an abnormal direction: from orifice to tip, such an appendix is abnormal. Under such conditions, it is not these changes in the appendix, itself, but the morbid reflexes stirred up in the oral end of the gut and in the stomach that invite surgical attention to the appendix. Such reflexes are interpreted by the patient as a discomfort, or a fulness in the epigastrium, an annoying eructation of gas from the stomach, seldom of fluid, and a consciousness that all is not well with his stomach; all these observations made by himself he calls collectively dyspepsia or if he is uncomfortably nervous at the same time, nervous dyspepsia. Constipation is often added to the above list of complaints under the term biliousness. The physical examination of the abdomen in this early functional stage is practically always negative. There may be evidence of gaseous distention and there may be a relative hyperesthesia over the right lower quad-

rant. Parenthetically, when it is recalled that distention of smooth muscle is, within proper limits, its normal physiological stimulus to contraction, a possible significance of gaseous accumulation within the stomach and colon of one of these individuals suggests itself. Indeed, rather than being, as is often supposed, the result of mechanical obstruction gas may purposely exist as a means of arousing intestinal peristalsis in an inhibited and otherwise obstipated gut.* The *x*-rays depict an active stomach and small gut and, often, a colon that empties within normal time. The gastric secretions run high or low. The fecal excretions throw no additional light upon the subject. Blood examination generally reveals lymphocytosis. In summing up such a case, one is at a loss to find a definite organic pathology. Unusual gastrointestinal motor activity with the prominence of gaseous distress, constipation, and lymphocytosis; and, above all, the tendency of these symptoms to periodicity should suggest the appendix as a possible etiological factor. At this time, appendectomy can be performed without a single unfavorable result, providing the patient has received the benefits of thorough conscientious preoperative study which makes unnecessary prolonged adhesion-forming abdominal exploration and providing the operator's technique is expeditious and accurate. If the appendix is not re-

*This opinion has been further borne out in a recent case of adynamic obstruction strikingly displayed five days after a colectomy with advancement of the ileocolic sphincter which was relieved by a spontaneous bowel evacuation immediately following ileostomy. The small bowel had been distended with gas far beyond physiological limits and peristaltic contraction became impossible. When, however, sufficient gas had been removed to bring this pathological distention within normal proportions peristalsis promptly ensued.

moved the patient is forced to live the life of a chronic semi-invalid unless the stage of complications intervenes and compels its removal.

The complications of a persistent luminous appendix demand surgical relief if it has not been removed for any other reason. These are complete obstruction which converts a semioccluded loop into a doubly occluded and obstructed intestinal loop and acute suppurative inflammation. Fortunately purulent appendicitis is becoming very rare. It seems as though acute appendicitis can be explained only upon our own ignorance or upon the perverseness of the patient. Certain it appears that the stomach can not be continually bombarded by irritating stimuli from an aberrant appendix for an indefinite period without undergoing some irreparable damage. At this stage, the removal of a grossly pathological appendix eliminates the local sore but not the injury to the other organs. Hence it is that some of our patients are relieved and some are unrelieved by appendectomy. On the other hand impaction gives rise to colicky pain which adds a darkening color to the usual dyspeptic or bilious attack experienced by the patient. Protective spasm and local tenderness with or without subsequent temperature and leucocytosis should enforce appendectomy for complete obstruction.

An interesting case of an appendix harboring oxyuris and undergoing purulent inflammation behind an enterolith was recently observed in a young woman. The father of the girl had previously been relieved of gastric symptoms by appendectomy for a large occluded and congested but uninflamed appendix. The latter is representative of a large proportion of cases. No detailed histories will be given but the single following case report which is particularly illustrative:

Mr. G. H. L., a business man, 45 years of age, born in U. S. A. Gives a family history of gastro-intestinal ailment. Had bilious attacks for the past twenty years; the most disagreeable feature is frontal headache. Periodicity has become increasingly marked and attacks come at more frequent intervals. The eructation of gas is the most conspicuous stomach symptom. Has undergone various medical treatment without satisfactory relief. He has a crepitant cecocolon and tenderness in the epigastrium. He has some secondary anemia 9,200 leucocytes with a differential of polynuclears 38, lymphocytes 56, and eosinophiles 2; indicanuria, feces with no blood, parasites, nor ova; and a gastric analysis of 16 c.c. HCl and 20 c.c. of total acid. Fluoroscopic and *x*-ray examination by Hobbs show a stomach and colon below the normal or average limits and an *appendix that does not empty within six days*. First seen Feb. 2, 1917; study completed Feb. 16, 1917. On Feb. 19, 1917, was seen at his home suffering from a "bilious attack" and from pain about the umbilicus. He had right sided rigidity and tenderness, temperature of 99°, pulse of 60, and respirations of 20. The differential count at this time was polynuclears 79, lymphocytes 21. Operation performed the same day disclosed a short, thickened appendix, distended at the tip and tightly contracted proximally about a fecolith 3 cm. in length. Convalescence has been uneventful. He returned to work within a month and to date has been free from his "bilious attacks."

It is believed that the above case is quite typical of many individuals who submit to appendectomy. Undoubtedly, he should have been relieved of his appendix twenty years ago. He had passed out of the early functional stage into the stage of appendical complications; namely, obstruction and inflammation.

To summarize: The appendix which outlives its functional usefulness becomes an abnormal appendix. Under such conditions it may be looked upon as a semioccluded and a semiobstructed intestinal loop. Such a loop apparently becomes a source of

irritating stimuli to the rest of the alimentary tube, particularly the stomach. Impaction may convert this semioccluded into a doubly occluded loop or acute suppurative appendicitis may supervene. It is most satisfactory to the patient and most economical to the State to perform appendectomy in the premonitory stage of "appendicular dyspepsia."

616 Madison Avenue.

Intestinal Obstruction

JOHN WILLIAM DRAPER, M.D.
Fellow of the American College of Surgeons
NEW YORK

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Intestinal obstruction is no longer an abstruse laboratory study, but a many-sided problem of quite as great interest and importance to the abdominal surgeon as to the surgical physiologist.

This is a significant note, bearing on the growing value of surgical physiology to medical development in general and on the immediate importance of the new departments of comparative surgery and medicine. Again, and from another standpoint, the broadening of this subject popularizes in our profession the biologic point of view, clearing the horizon as to the origin, relationship and destiny of man. This emphasizes the geocentric as opposed to the homocentric conception of the universe in which we dwell. It helps to teach the supreme fact that far from being the central pivot of interest and importance, man, like his kindred vertebrates, is relatively unimportant; a link only in the great chain of animal and vegetable life. This has not, in the past, been the accepted doctrine and many of the medical prejudices and stumbling blocks with which we are beset have come from a failure to recognize man's place in nature.

Is it not along these abstract lines of progress that we are led by experimental study to just as important truths as are to be found in the concrete methods of laboratory work? I often think that the one is sometimes lost sight of in the search for the other and that we are apt to lose much from the broader conception of life and its variations from our arbitrary normal in a too austere and exclusive dependence on purely technical facts, particularly those relating to morphology.

* From the Laboratory of Surgical Research, New York University.
* Read before the Section on Obstetrics, Gynecology and Abdominal Surgery at the Sixty-Seventh Annual Session of the American Medical Association, Detroit, June, 1916.

I have said that today intestinal obstruction is of quite as much interest to the abdominal surgeon as to the surgical physiologist. What are these points of interest and how has the correlation of interests come about?

There is a certain well-defined clinical syndrome which has been somewhat loosely defined as auto-intoxication. So often is there a delay or at least an irregularity in the onward course of the intestinal contents that we are forced to concede a probable relationship between cause and effect. The moment this is granted do not our abstract laboratory studies as to the cause of death in obstruction enter into very close applied relationship with this clinical syndrome? The question as to the origin of the toxemia in dogs assumes growing importance if proved to be allied to the etiology of constipation in man. Lynch[1] has conclusively proved by careful study of the results of ileostomy upon numerous human beings that the amazing improvement noticeable in all these cases is due far more to a change in the biochemical conditions than to any mere relief of the intestine from mechanical work or to a drainage of intestine contents with bacteria and their products. These contributions by Lynch on the terminal ileum and colon have greatly enhanced the value of the winter's studies on the stomach and duodenum, and have shown that the hope for future progress in understanding the alimentary canal in health and disease lies in considering it as a whole, rather than as separated by arbitrary morphologic barriers. The researches of Barber[2] on the neuromuscular control are equally significant.

No truer words relating to the alimentary canal have been written than by the surgical physiologist Sweet,[3] who says, in concluding one of the most schol-

1. Lynch and Draper: Developmental Reconstruction of the Colon Based on Surgical Physiology, Ann. Surg., 1915, lxi, 166; The Infected Colon and Its Surgery, Med. Rec., New York, 1915, lxxxvii, 983; Anastalsis and Therapy of the Colon, Am. Jour. Med. Sc., 1914, cxlviii, 828. Lynch, Draper and Lyon: Contribution to the Surgical Physiology of the Colon, Ann. Surg., 1915, lxii, 441. The foregoing articles are contained in Surgical Pathological Physiology, Volume I, New York University. Draper, J. W.: Studies in Intestinal Obstruction, THE JOURNAL A. M. A., Sept. 26, 1914, p. 1079. Lynch and Draper: The Protective or Esoteric Symptoms of the Alimentary Canal, Virginia Med. Semi-Month., 1916, xx, 601.

2. Barber, W. Howard: Dilatation of the Duodenum, Ann. Surg., 1915, lxii, 433; Surgical Pathological Physiology, Volume I, New York University.

3. Sweet: Intestinal Obstruction, Ann. Surg., lxiii, 720.

arly papers that has yet appeared on intestinal obstruction:

> We are aware that surgery already possesses a plethora of theories; but as long as a theory is given its proper valuation as a theory, as a working hypothesis, and is not accepted until supported by such an array of facts that the theory has itself become a fact, these theories offer the only means of progress in a field where so little is known.

Feeding Experiments.—For the past four years we have been interested in studying the effect on obstruction toxemia of feeding jejunal and ileal homologous epithelial cells to duodenally obstructed dogs. Two reports have been made, both suggestive that some improvement in the obstructed animals resulted. The series observed by us in the past year, however, and under like conditions fails to show any prolongation of life from the treatment. In fact the average duration of life was less than in the control animals, thus casting doubt on the further value of this working hypothesis. The result in this form of therapy is therefore still in abeyance.

TABLE 1.—DUODENALLY OBSTRUCTED DOGS, FED JEJUNAL AND ILEAC MUCOSA; 1916 SERIES

Dog Number	Average Pulse	Duration of Life, Hours
110	133	119
111	133	46.30
124	178	69.30
136	169	68.30
137	161	90.30
138	170	142
161	183	72
162	188	70
216	175	47.30
217	177	119.30
	1,667	845
Average	166 plus	84½

TABLE 2.—DUODENALLY OBSTRUCTED DOGS

	1913 Series			1916, Mucosa Fed
	Mucosa Fed	Emulsion Fed	Controls	
Average pulse	156	157.4	156.3	166.7
Duration of life, hours	164.8	104.4	88.5	84.5

Duration of Life in Esophageal and Gastric Occlusion.—H. H. Janeway[4] in 1910 noted that esophageal obstruction often resulted in death without discoverable cause. Of five dogs obstructed by us transpleurally in 1916 all died of empyema within three days, thus destroying our statistics in this field.

On three dogs obstructed at different levels in the stomach, the following observations were made: average duration of life, 116 hours; average pulse, 187. Clinically, these dogs differed widely from those obstructed in the duodenum. There was no spasticity of the hind legs. Vomiting was rare. All signs pointed to a less acute intoxication. Nevertheless, they died. Our previous experiments have proved that dehydration is not a factor of any more importance in this than in toxemias due to other causes, and it is hard to understand how the duodenum can stand in causative relation, being aboral to the obstruction. Still for all it may so stand. The fact that obstruction anywhere aboral to the pharynx causes death is significant. Eisberg has noted a ratio between gastro-esophageal and ileocolonic obstructions in relation to duodenal which we hope to report on later. If confirmed this ratio will support our contention that the beginning and end of the canal have many points in common and that toxicity varies inversely with the digestive power.

Effects of Introducing into the Peritoneal Cavity the Scraped Epithelium of Obstructed and Non-obstructed Dogs.—The object of this was to determine if possible what change if any had taken place in the epithelium as regards toxicity, or whether any toxicity could be ascribed to the same cells under different conditions. From cultures of the mucosa introduced in three cases only colon organisms were found. Out of a series of ten dogs eight died of peritonitis, while two showed symptoms of duodenal obstruction, namely, hemorrhage from the rectum and tremors. It is to be noted that the first is not a common symptom of duodenal obstruction, but has been observed by us to occur. It is undoubtedly due to congestion of the rectum and colon from the elimination of toxins. The results of this series are absolutely inconclusive, but an improvement in the technic might help. We incline

4. Personal communication to the author.

to the belief from these studies that the toxin is not in the cell itself, but is a product of its abnormal activity.

Isolation of Intestinal Doubly Occluded Loop with Reconstruction of Alimentary Canal and Curettage of Epithelium, Having Cells within the Loop.—In four out of five cases rupture occurred on the antimesenteric border. There was great distention. In two cases the loops were black, due either to gangrene or to autolysis. The average duration of life was forty-eight hours. The peritonitis was of the most virulent type. There was much trouble with hemorrhage after the curettage. Whipple's[5] technic of removal by sodium fluorid is evidently preferable. The result of this series was negative.

Thiry-Vella Fistulas, a Single Occluded Duodenal Loop, Drained Externally; Reconstruction of Canal.—It is well known that animals so treated do not prosper. After four or five days they show marked clinical signs of toxemia and a loss of weight. They usually die soon after. If curetted, these signs do not appear. This is in accord with most other observers, but at variance with Murphy and Brody's findings.

From six dogs, 1,000 c.c. of loop fluid was collected as follows: double duodenojejunal occlusion and invagination of ends; loops about 25 cm. long. There was no difference in the rate of fluid accumulating in the loops, whether the continuity of the intestine were reconstructed or not, or whether gastro-enterostomy were done. In all three types we had loops in which no fluid accumulated. We are at a loss to explain why. We did not interfere with the venous return.

Attempts to save the animal's life by excision of the loop after the symptoms had developed and where reconstruction of canal had been done was futile except in one case. A proteose was not found in the 1,000 c.c. referred to above. Perhaps this was due to the fact that we used infusorial earth to hasten the alcoholic precipitation. According to Whipple's technic it should have stood for twelve weeks. With this exception the method used was the same as his. The effect of injecting the final precipitate into one dog intravenously was very marked prostration, temperature of

5. Whipple and Stone: Intestinal Obstruction: Study of a Toxic Substance, Jour. Exper. Med., 1913, xvii, 286.

105, no vomiting, no diarrhea, no spasticity, no convulsions or tremors. There was recovery after twelve hours.

We have noted the great difficulty in saving these animals after a doubly occluded duodenojejunal loop has been left in for more than thirty-six hours or often for less time. This we have assumed to be due to an impairment of the functional power of the liver based on the studies of Schultz and the writer. They noted a diminution in the camphor-glycuronic pairing power

TABLE 3. NITROGEN RETENTION AND ALKALI RESERVE IN DOGS SUBJECTED TO INTESTINAL OBSTRUCTION *

Normals	Nonprotein Nitrogen, Mg. per 100 C.c.	Creatinin, Mg. per 100 C.c.	Alkali Reserve, per Cent.
No. 280	51.3	0.1	28
291	44.4	0.1	50
292	43.3	0.1	48
308	29.0	0.65	43
307	39.0	0.8	38
(Tumor of Spleen) (Encapsulated hematoma)			
Doubly obstructed duodenojejunal excluded loop:			
Twenty-four hours after operation:			
No. 281	52.3	...	52
298	47.3	0.1	42
299	41.4	0.1	61
Forty-eight hours after operation:			
No. 298	63.1	0.3	60
299	82.8	0.55	48
304	85.0	1.00	57
305	101.0	2.00	..

* As far as we have gone three things are noticeable: First, a rise in nonprotein nitrogen; second, a rise in creatinin; third, it seems to grow more alkaline. These changes seem most noticeable after forty-eight hours.

in the liver of duodenally obstructed dogs and assumed that this might also indicate decreased power to detoxicate autogenous duodenal toxins. In such acute conditions as those under consideration there is no time for morphologic changes to show and the change in amount of liver fat is not a reliable index of the organ's protective efficiency.

Frazier and Peet[6] have introduced a most ingenious method to study this point, namely, an Eck fistula. It is more accurate and less cumbersome than Tollen's glycuronic technic.

6. Frazier and Peet: Ann. Surg., June, 1916.

Whipple in a comprehensive study of the subject has isolated a proteose from such doubly occluded loops. This he considers to be the direct toxin from the mucosa and in this supports Roger, who some years since showed the presence of proteose.

Sweet, while agreeing that the toxin undoubtedly originates in the cells of the duodenum, points out that an acceptance of the proteose hypothesis of Roger and Whipple entails a modification of our present understanding of protein digestion and gives strong proof of the toxic activity of the pancreas in intestinal obstruction. He points out the clinical resemblance between acute pancreatitis and duodenal obstruction.

CONCLUSIONS

The cause of death in intestinal obstruction is still unknown, but all recent studies point to aberrant activity of the duodenal and probably pancreatic cells. The old hypothesis that the toxin is of bacterial or food decomposition origin may be looked on as discarded. Dehydration is of no greater importance in this than in other toxemias.

There is an important ratio between the toxicity of the intestinal epithelium and its digestive power.

The intricate syndrome autotoxemia occurring in man will be better understood when we know the cause of death in duodenally obstructed dogs.

I am indebted to Dr. Gettler of the department of chemistry, New York University, for Table 3, which appears to show some interesting and constant changes in the blood of duodenally obstructed animals.

ABSTRACT OF DISCUSSION

Dr. H. D. Johnson, New York: When the intestine is obstructed, death results from either water starvation, food starvation, or both, or from toxic absorption. In my clinical work I have tried to differentiate these classes of cases and to treat them accordingly. I have thought out some death lines. I had a case of obstruction in the stomach at the pyloric end. There was regurgitation of water and no toxic symptoms whatever so far as I could see. I have not seen the high obstruction of which Dr. Draper speaks. The nearest approach to it was in a case in which there was obstruction at about 4 feet down the jejunum, in which the symptoms were those of acute toxemia as well as water starvation. It is well to remember that these patients not only do not take water,

but the water which they have is not utilized. The toxic symptoms are less acute as you get away from the pylorus and into the region of the large intestine, where the toxic death line is very long delayed. The point I would bring out is to provide drainage. If you will make an end to side anastomosis and put in a rubber tube in these cases needing daily drainage you will produce a water-tight bowel anastomosis. If you have not the proper tube, cut off a glove finger and make a water-tight joint between the glove finger and the intestine through which you may irrigate the bowel and through which gas may escape. In one case of high obstruction I kept the patient alive for an indefinite period, feeding by rectum and through the anastomosis. The tube should be dropped straight into the bowel so that there will be no angulation. If normal action of the bowel is restored, either by nature, or surgery, that fistula will not stay open.

Dr. C. Hugh McKenna, Chicago: About seven years ago, when Dr. Draper first brought out his work on acute intestinal obstruction, Dr. Bloodgood of Baltimore directed my attention to this work because I was somewhat interested in the clinical phase of the subject. Having had one or two interesting cases in which I had performed enterostomy, I started some experimental work along the line suggested by Dr. Draper, and since that time we have operated successfully in eight human cases of acute obstruction by performing a jejunostomy, preferably in the upper part of the jejunum. These patients are operated on under local anesthesia. The jejunum can be picked up without unnecessary manipulation of the gut, which is important, and an enterostomy is performed by attaching the intestine to the skin alone by Lembert sutures, making it for the time being hermetically sealed so that none of the secretions can run back into the peritoneal cavity. It has been interesting to note that at the time of the resection of the bowel or closure of the fistula five or six weeks later, a small tip of gut was pulled off at right angles to the jejunum, so that for two weeks preceding the operation for closure practically the entire intestinal content continued down with very little passing out on the abdomen. The welfare of the patient seems to be in proportion to the position of the opening in the small intestine, whether high up or low down, and the presence and amount of pancreatic secretion which is poured out on the skin of the abdomen is indicative of a high enterostomy. Every abdominal surgeon will know this to be true. In other words, the question of getting an enterostomy high up in the small intestine is the all-important part of the operation, just as has been proved by Dr. Draper and other men doing this work. In our experimental work the frequency of death was in proportion to the position at which the obstruction was caused. From the work of Whipple and others, I am inclined to believe that the fatal factor in ileus is due to a normal physiologic intra-enteric

secretion that comes probably from the duodenum and which, when the peristalsis of the intestine is interfered with sufficiently to block up this secretion, gives us one of the most powerful toxins, which condition if not corrected produces death. To those who claim that we may gain results by placing a tube down through the stomach and into the duodenum for lavage, I wish to say that my clinical experience has taught me that there must be a permanent drainage until the normal tone of the duodenum and upper intestinal tract has been entirely restored.

Dr. John William Draper, New York: It is very encouraging to those who spend a great deal of time in abstract studies to feel that the results will be of use in applied surgery. Dr. Johnson referred to water starvation. It was with the hypothesis of water deprivation in relation to this toxemia that we performed the following experiments. We took a series of dogs and gave them pilocarpin in very large doses. We then suddenly obstructed a similar number. The former lived; the latter died. All tissues were then excised. I cannot give the exact figures, but there was less than half the amount of water in the tissues of the pilocarpinized animals than in the animals dead with intestinal obstruction. Although twice as dry, the pilocarpinized animals were clinically normal and healthy in every respect. It is well known that with an increased water content, with dilution of the toxemia, any toxic animal will live longer. Dr. McKenna spoke of the desirability of draining away the material which has accumulated above the obstruction. This is a subject in which I am much interested, but of which we know little. I am, however, quite familiar with his work. Statistics collected at the Johns Hopkins by McGlannan would seem to indicate that better results were obtained from such drainage, but it is about "fifty-fifty." It is quite conceivable that this material which everybody knows is very toxic may be of great value as a detoxinating agent for the host itself, although toxic to other individuals.

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Intestinal Obstruction, Complete and Incomplete

JOHN WILLIAM DRAPER, M.D.
Fellow of the American College of Surgeons
NEW YORK

INTESTINAL OBSTRUCTION, COMPLETE AND INCOMPLETE*

JOHN WILLIAM DRAPER, M.D.
Fellow of the American College of Surgeons
NEW YORK

A complete obstruction of the bowel near to the stomach usually causes death in man and in the lower animals in less than 100 hours. A similar obstruction in the aboral portion of the intestine may not cause death for a week. An incomplete obstruction at any point in the intestine causes symptoms that differ from the complete form only in degree. Problems connected with obstruction are among the most interesting and important in medicine. What is the toxic agent which, with tachycardia and convulsions, but without elevation of temperature, destroys life so speedily in duodenal obstruction, leaving no discoverable trace at necropsy? Is it a product of bacterial infection, or is it due to perversion of the great glandular system of the alimentary canal? Is it analagous to the death caused by the removal of the parathyroid or other glands? Does the mere blocking of the intestine in this, biochemically the most active portion of the canal, amount to an actual severance of an interglandular relationship that is not compensated for through the blood vessels or other channels, an ancient and potent interaction that is necessary to the maintenance of life and for the continuance of which an open intestine is necessary? Why is it that the nonprotein nitrogen and other components of the blood increase enormously after duodenal obstruction, while no such change is noted in ordinary bacterial infection? Is a proteose similar to that described and isolated by Whipple the cause of death, or is the toxic substance, like prosecretin, of so delicate, evanescent and unstable a character as to defy detection by test tube anal-

* Read before the Section on Gastro-Enterology and Proctology at the Sixty-Eighth Annual Session of the American Medical Association, New York, June, 1917.

ysis? If so, is not this an example of the truth of Haldane's recent assertion that we are emerging physiologically from a materialistic to a vitalistic basis of research? What is constipation if not a protective symptom analogous to abdominal rigidity which seeks to give surgical rest when and where needed? What relationship, if any, can be shown to exist between the well known chronic symptoms of intestinal toxemia and the little known but much dreaded symptoms of duodenojejunal obstruction? Why do certain of these chronic toxemics improve when the diseased and often pigmented cecocolon is removed? Is it possible to find any efficient medical treatment until some of the foregoing questions are answered? If surgical, is a given case to undergo resection or some form of anastomosis? What is to be expected of the different forms of anastomoses that produce partial exclusion? May there be recognizable hereditary structural changes predisposing to the occurrence of such chronic subobstruction as one often sees clinically in the chronic intestinal invalid? If so, may one utilize some such type of classification as that of Bryant—herbivores, carnivores and neutrals to aid in the diagnosis and care of these cases?

These are some of the engrossing problems which confront the student of atypical conditions in the alimentary canal. Some of them are answerable. Many are still open to free discussion. Of the remainder we frankly know little or nothing. It is axiomatic, however, that no treatment, either medical or surgical, can be of real value unless it is based on a greater knowledge than we at present possess. Researches, therefore, into the physiologic pathology of the alimentary canal are evidently of the utmost importance.

Turning to a brief consideration of these questions, I may state that in a paper published eleven years ago from the Laboratory of Experimental Surgery at Columbia,[1] I related a series of experiments made during the previous years as a result of which we had concluded that neither shock nor the absorption of food products nor bacterial infection had anything whatever to do with death in duodenal obstruction. I found that by placing a triangular ligature between the

1. Draper, J. W.: Observations upon Form of Death Resulting from Certain Operations upon the Duodenum and Jejunum, Surg., Gynec. and Obst., May, 1906.

stomach and the small intestine just aboral to the point of total obstruction, this ligature would produce drainage in about seventy-two hours, and that there was a very constant line, which I referred to as the lethal line of the duodenum, oral to which obstructions were fatal under the conditions indicated, but harmless if made aboral to it. From this, and from the fact that necropsies, most carefully and repeatedly made, failed to demonstrate any lesion whatsoever save capillary dilatation of the terminal colon and occasionally of the stomach and liver, I "determined that death was due to some more subtle factor than those considered . . . that there might be a relation between this form of intoxication, if such it be, in dogs, and the so-called tetany of human beings; that the question seemed to have resolved itself now into a determination as to whether death is due to an intoxication resulting from a disturbance of the balance of the secretions which pour so plentifully into the intestine in this particular region; . . . whether secretion or other secretions from the duodenum itself had anything to do with the cause of death."

In a paper published one year later,[2] quoting Wilms, I noted that death from duodenal obstruction subvenes with extreme rapidity, and that up to that date all patients were believed to succumb to toxic absorption, resulting from the decomposition of intestinal and stomach contents. Starvation and lack of absorption of water, which in those early days had already been thought by some to be a factor and which have latterly been brought into great prominence, notably by the valuable researches of Hartwell and Hoguet, were looked on as "hardly to be considered when one reflects that absorption of water takes place almost entirely in the colon, and can therefore not be materially influenced by the position of the obstruction in the small gut." Observations that we have made show conclusively that putrefaction has nothing whatsoever to do with the cause of death in intestinal obstruction.

In 1914, in a paper[3] based on researches made in the Surgical Research Laboratories of the Mayo Clinic and New York University, I concluded with Schultz that

2. Draper, J. W.: Is Death in High Intestinal Obstruction Due to the Absorption of Bile? (Rockefeller Institute Fellowship Research), Ann. of Surg., October, 1907.

3. Draper, J. W.: Studies in Intestinal Obstruction, The Journal A. M. A., Sept. 26, 1914, p. 1079.

the power of the liver to pair camphor and glycuronic acid is impaired after duodenal obstruction. This is presumably an evidence of impaired liver function. It is, however, not reflected in the histologic appearance either grossly or microscopically.

The decrease in the water-content of the tissues in duodenal obstruction is about the same as obtains after salivation by pilocarpin for four days or after fasting for seven. As this decrease produced no visible change in either case before euthanasia, it is reasonable to believe that it produces none in intestinal obstruction. The loss is 10 per cent. The duodenal obstruction (death) undoubtedly arises from an interference with cellular reactions of the intestinal epithelium. The resulting toxins undoubtedly are at least in part eliminated from the stomach and colon.

I reported also the increase of nonprotein nitrogen in duodenal obstruction, concluding that all recent studies "point to aberrant activity of the duodenal and probably pancreatic cells; that the old hypothesis that the toxin is of bacterial or food decomposition origin may be discarded; that dehydration is of no greater importance in this than in other toxemias; that there is an important ratio between the toxicity of the intestinal epithelium and its digestive power; that the intricate syndrome autotoxemia in man will be better understood when we know the cause of death in duodenally obstructed dogs."

CHEMICAL BLOOD PICTURE IN COMPLETE DUODENAL OBSTRUCTION *

	Before Operation	Hours After Operation			
		24	48	72	96
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Nonprotein nitrogen...	44	70	102	92	136
Urea nitrogen	18	48	70	65	112
Creatinin	0.1	0.4	0.9	0.3	0.5
Uric acid	0.7	0.9	2.5	21.5	15.7
Sugar	125	110	111	143	150
Alkaline reserve	67	68	55	52	50

* Dog 209, Department of Chemistry, New York University, May, 1917. No infection; no elevation of temperature; average pulse, 150; tremors; death, one hundred and tenth hour.

Through the courtesy of Professor Gettler of the department of chemistry, New York University, I am now able to report further studies in the chemical picture of the blood in duodenal obstruction in dogs, and to contrast it with his well known studies along this line in human intestinal toxemias and in infections. Thus a great deal of evidence has accumulated in the

past fifteen years pointing to the accuracy of my hypothesis that death in duodenojejunal obstruction is not due to any form of bacterial action whatsoever, or to toxins derived from the food, but to a disturbance of the hormone or enzyme producing activities of the intestinal epithelium and the consequent production of toxic bodies that cannot be isolated by ordinary chemical analysis—in other words, that death is caused by conditions analogous to those induced by removal of the parathyroids or other glands. If this is true, and if my failure to corroborate Whipple's efforts to prove that a proteose is the cause of death is not due to inaccuracies, then the evidence points more than ever to the gland perversion or inhibition theory already referred to.

TECHNICAL STUDIES IN DOGS

Investigations with a view of determining the best technic for developmental reconstruction (right side colonic resection) were conducted by resecting 10 cm. oral and 10 cm. aboral, using the ileocecal valve as the dividing line. Three forms of anastomosis were used, "end to end"; "end to side" and "side to side." The majority of the animals developed a semisolid or watery stool after operation. Stools became normal in seven days, on an average. From a technical standpoint, lateral anastomosis was the easiest to perform. Although it was the most difficult and showed the greatest mortality, end to end anastomosis gave the best postoperative results. Dilatation of the oral end of the intestine was noted both in lateral and in end to side anastomosis. The "end to side animal" vomited postoperatively for several days, and was the worst as regards vomiting. There was less vomiting after the end to end anastomosis. Roentgenoscopy was applied to all animals within two and a half to three hours after the bismuth meal given before and after operation.

Roentgenoscopic interpretations:

Best results—end to end—no effect as regards delay, local or reflex.

Moderate results—end to side—moderate delay in stomach; no anastomotic delay.

Worst results—lateral—marked delay in stomach (reflex), slight at anastomosis.

Prof. George Wallace of New York University kindly directed for me the intravenous introduction of a chemical residue derived from the treatment (Whipple's technic) of 1,000 c.c. of proximal loop fluid from duodenally obstructed dogs by Professor Gettler, department of chemistry. We were unable either to cause the dog's death by intravenous injection of the entire amount collected, or to show any reaction whatsoever. Dr. Stark made the obstructions and collected the fluid.

SUMMARY

Our experiments on animals have led us to believe that death in high intestinal obstruction is due to a perversion of enzymal function. The symptoms are so fulminating in character as compared with those of obstructions aboral to the point of maximum physiologic enteric activity that until recently they have received far more attention both experimentally and clinically than those of the caudad obstructions.

This is true of both complete and incomplete types. It is the purpose of this paper to correlate the two and to show not only the close relationship which actually exists but also to point out the great importance of experimental surgery to clinical progress.

It is natural, after all, to expect that in a segment of the intestine so highly specialized as the duodenum, perversion of function should rapidly reach a climax. Here the most complex functions of digestion are consummated with rhythmic precision. It is not surprising that so gross an insult as must attend obstruction must be followed by violent biochemical reactions. A marked acidity of the gastric contents causes the pancreatic juice to be poured out, and initiates peristalsis in the gallbladder. Very high acidity causes a marked flow of bile. On the other hand, the cecocolon bears such a close resemblance to the stomach both functionally and mechanically, and these characteristics are so gross as compared with those of the duodenojejunum that they necessarily do not react so actively to interference. Embryologically they have practically the same developmental history. Until recently the cecocolon has received only limited study as compared to the stomach. This, too, is natural, both because of the nearness of the stomach to the duodenum, gall-

bladder and pancreas, and because many of the lesions of the colon are at first referred to the stomach. Only a few years ago Moynihan in his classic work on duodenal ulcer gave what he considered a typical picture of duodenal ulcer symptomatology which was thought to be pathognomonic, but which we now know can be caused by a chronic appendix, an elbow adhesion, a gallbladder, a long sigmoid or other lesions. He later admitted that it is almost impossible in some cases to differentiate intra-abdominal lesions through a study of their subjective symptoms alone. It is necessary to have a clear understanding of comparative embryologic pathology in order to appreciate the conditions often encountered when the human abdomen is opened. One is surprised to hear frequent and bizarre efforts to explain by mechanics atypical variations in the sigmoid that have a patent embryologic origin. The sigmoid and the cecum are two of the most variable organs in the body, and the esoteric stomach symptoms that arise are due to the variations rather than vice versa.

The intestine is developed by buds. This permits of wide variations in type. The primitive intestine is a good deal like that of the fish, two loops lying side by side. Like other theories that are mechanical in basis, the mechanical rotation of the intestine is now set aside, and it is shown to be a well ordered and systematic process depending on accommodation to existing conditions and regulated by intra-abdominal pressure. In the embryo the liver is so large that very little room is left for the intestine, and all the bowel, except its beginning and end, develops for a period outside the abdomen.

Now, as the liver fails to keep pace with the growth of the abdomen, the pressure within is diminished and the intestine gradually recedes within, until finally the primitive cecum and transverse colon accept the place allotted to them and gradually recede to a resting place over the duodenum and in contact with the kidney—the so-called second position. Here it remains until after birth, when it usually migrates toward the iliac fossa. During the process of rotation and subsequent migration, many irregularities may arise, which account for much adult pathology. Notable among these we may mention frequent delamination of the peritoneum and failure of fusion. My colleague,

Jerome Lynch, has given much thought to these conditions. We believe that adventitious membranes are not in themselves harmful, but if, as a result of failure of fusion, partial obstructions periodically supervene, resulting in atrophy and pigmentation, as observed by our colleague, McFarland, in fresh cecal tissue, then those adventitious membranes are converted from normal peritoneum to connective tissue bands. Every one is aware that should this process continue, contracture follows and the typical elbow deformity previously described by us is inevitable. Furthermore, we are of the opinion that the dividing of normal extraneous peritoneal bands very often may precipitate what I have just described.

These physiologic and embryologic considerations help us to realize that, while there are great variations in the alimentary canal, it must be considered as a whole and that throughout it is subject to the same fundamental laws. What is true of one part is in a limited and discretional sense true of the rest, and this, in spite of the singular analogies between the gastric and colonic ends, which are purely mechanical, as contrasted with the duodenojejunum, which is almost wholly biochemical in action.

Thus, one is tempted to hazard the hypothesis that the syndrome in man called intestinal toxemia is really a subacute or chronic manifestation of the acute duodenal toxemia observed in obstructed dogs, modified perhaps in many ways by the toxins of a secondary bacterial infection. I have been forced to a favorable consideration of this hypothesis by an exhaustive study of twenty-nine cases of developmental reconstruction of the colon in which the right colon has been removed either by my colleague, Jerome M. Lynch, or myself, and recently reported by me.[4] Satterlee, Smythies, Einhorn and others have repeatedly noted that marked constipation can occur without the symptoms of toxemia, and it is evident that constipation is a protective symptom. We are miserable and stupid when constipated, but not because of the protective symptom constipation. We are constipated because of intra-enteric glandular disturbances similar to, but less severe than, those which occur in a duodenally obstructed dog.

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4. Before the 1917 meeting of the American Society of Gastro-Enterology.

That bacterial toxins serve to complicate the syndrome of autotoxemia is not to be questioned, particularly in view of the researches of Satterlee, who has achieved such marked results in otherwise hopeless cases through the injection of autogenous colonic vaccines. His recital of a fatal case of intestinal obstruction that produced such marked muscular spasm as to be mistaken for tetanus is a valuable addition to the literature. In Robert Brown's case of cecosigmoidostomy, which was afterward cured by the developmental reconstruction of the colon, the patient suffered from typical tetanoid seizures in the hands until relieved by operation.

Thus, our human and experimental animal studies continue to support the nonbacterial biochemical theory as to the cause of death in obstruction, and also to yield additional evidence that the symptoms of human autotoxemia have a common origin with those of a duodenally obstructed dog.

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INTESTINAL OBSTRUCTION

CONTINUED STUDIES *

H. B. EISBERG, M.D.
AND
J. W. DRAPER, M.D.
NEW YORK

Additional evidence is accumulating that death caused by intestinal obstruction is due to toxins originating in the epithelium of the duodenum and its appendages. Duodenal transplantation is, therefore, a satisfactory method for the experimental study of the cause of death in obstruction.

Rogeré, and more recently Whipple and his associates, have laid special emphasis on a proteose from the duodenal region. Sweet and his associates have laid special stress on the pancreas. Dragstedt, Moorhead and Burcky, on the other hand, again take up the bacterial origin of this toxemia.

Our continuation of the study of this interesting problem has centered on three phases—transplantation, proteose isolation and obstruction ratio.

DUODENAL TRANSPLANTATION

The entire duodenum with its outbuds, the pancreas and liver, are first separated from the alimentary canal (Fig. 1). The pyloric end of the segment and the stomach are occluded, the duodenum is anastomosed to the ileojejunum, and posterior gastrojejunostomy is performed (Fig. 2). This constitutes the primary operation. From two to three weeks after, obstruction by section and infolding, 35 cm. aboral to gastrojejunostomy was produced (Figs. 3 and 7). This corresponds in position to the duodenojejunal obstruction as shown in the control (Fig. 4).

The results were as follows: Dogs operated on as above lived seventeen days in comparison with six

* From the Surgical Research Laboratory, New York University.
* Read before the Section on Gastro-Enterology and Proctology at the Sixty-Ninth Annual Session of the American Medical Association, Chicago, June, 1918

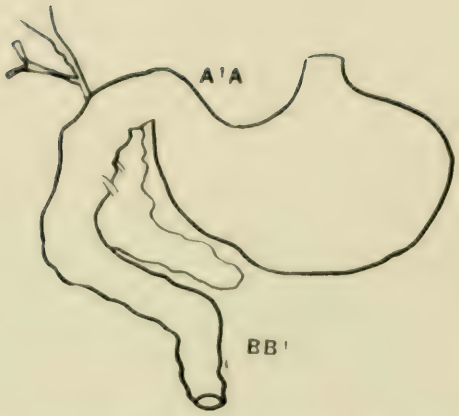

Fig. 1.—*A'A-BB'*, duodenum with its outbuds, the pancreas and liver.

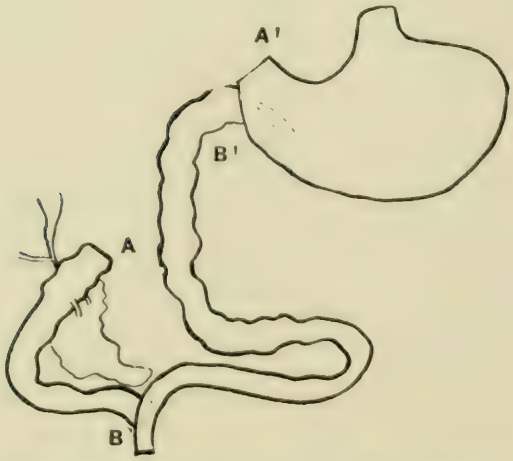

Fig. 2.—*A'*, oral occluded pylorus; *B'*, aboral jejunum anastomosed to stomach; *A*, aboral occluded pylorus; *B*, oral jejunum anastomosed to ileojejunum.

Fig. 3.—Same as Figure 2 with an obstruction.

Fig. 4.—*A*, obstruction at ileojejunum corresponding to obstruction at *C*, Figure 3.

days in the control animals and three days longer than after obstruction in any part of the small intestine except at the sphincter. Colonic obstruction caused death in fourteen days at the ileocecal sphincter, or in twenty-eight days if at the rectum. Moreover, and of great importance, is the fact that, clinically, duodenal transplantation prevented the occurrence of classical symptoms of duodenal obstruction such as tachycardia, tremors and spasticity, as described by one of us in the original report, in which it was pointed out that this condition closely simulated parathyroidectomy. After transplantation, the obstructed animal remained clinically normal for from seven to twelve days after operation. There was gradual increasing emaciation and occasional vomiting. The entire picture simulated that of rectal or esophageal obstruction with complete absence of all fulminating toxic symptoms.

The conclusion is that the duodenum, with its embryologic outbuds, furnishes the cause of death. If the jejunum creates a toxin it is certainly of low lethal grade.

PROTEOSE ISOLATION

In reference to the proteose of Rogeré and of Whipple, we have reported that we were unable to duplicate the experiments because of faulty chemical technic. Since then we have repeated Whipple's experiments and have caused death by the injection of the residue. Curiously enough, analysis of the charts showed that when fluid was obtained from blood loops, no reconstruction of the intestine having been done (Fig. 6), the intoxication was produced. If, however, end to end anastomosis or gastro-enterostomy (Fig. 5) were used to reconstruct the intestine continuity, the symptoms were either very slight or were absent.

To explain this phenomenon we offer Sweet's suggestion—that the toxic agent was formed in the duodenum but excreted into the occluded loop. This view is strongly supported by our observations after duodenal transplantation and also by the views of Dragstedt, Moorhead and Burcky, namely, that their animals with jejunal loops lived indefinitely if no rupture occurred, whereas, those with duodenal loops all died within from twenty-four to forty-eight hours, excluding those that died from rupture. Their inter-

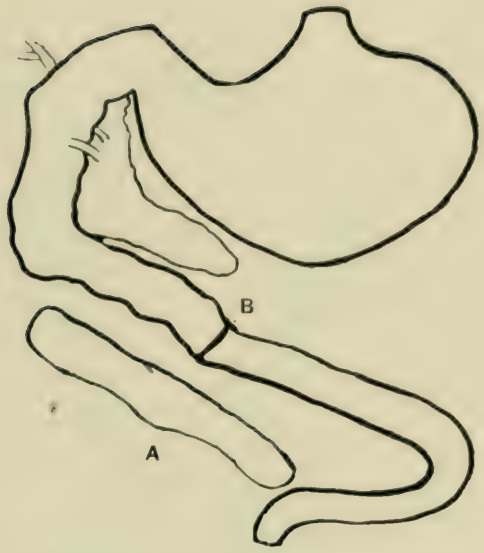

Fig. 5.—*A*, occluded loop; *B*, reconstructed alimentary canal.

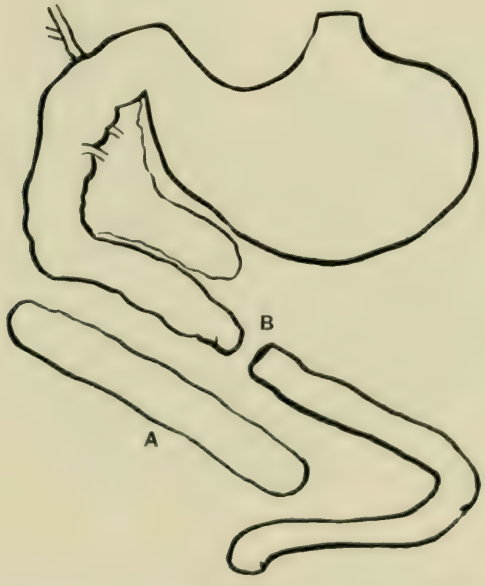

Fig. 6.—*A*, occluded loop; *B*, obstruction of alimentary canal.

pretation, that bacteria are the sole cause of death in intestinal obstruction, we cannot harmonize with certain facts. First, the duodenum is virtually bacteria free, as compared with the terminal ileum and colon, as Halsted and Cushing, as well as Brown and Blake and one of the writers, proved many years ago. Second, closed segments of the terminal ileum and of the colon, regions where bacteria abound, are not incompatible with long life.

TRUE LETHAL LINE OR POINT OF MAXIMUM OBSTRUCTIVE TOXICITY

Whatever the composition of the toxin of intestinal obstruction, which we believe to be of the same nature as the known endocrine secretions, partly because of the similarity of the symptoms after parathyroidectomy or duodenal obstruction, all observers have agreed that its most active manifestations occur following duodenal obstruction. There is a point in the second portion of the duodenum at which acute obstruction causes death more rapidly than elsewhere in the intestine. This point we have referred to as the true lethal line in distinction to the one which was described by one of us in relation to the twine triangular stitch for gastro-enterostomy and located some 20 cm. aboral to the true lethal line. Oral or aboral to this line there is a proportionate decrease of obstructive toxicity. While the exact ratio is not yet accurately worked out, one undoubtedly exists, and we have shown it roughly in Figure 8 to be approximately 1 : 4 in length of life, and 1 : 8 in length of intestine. These figures are arbitrary and may be shown by future work to be inexact; but the fact remains that there is a constant mathematical ratio that can be determined by further experiment. It may resemble the healing curve of Carrel. Lynch has suggested that there is normally some biochemical product brought down from above similar in nature to prosecretin. With this view we are in hearty accord.

SUMMARY

Duodenal transplantation definitely shows that the duodenum and its appendages, singly or collectively, produce the lethal agent which causes death in intestinal obstruction.

A proteose may be isolated under certain conditions. This will cause death if injected. Further definite

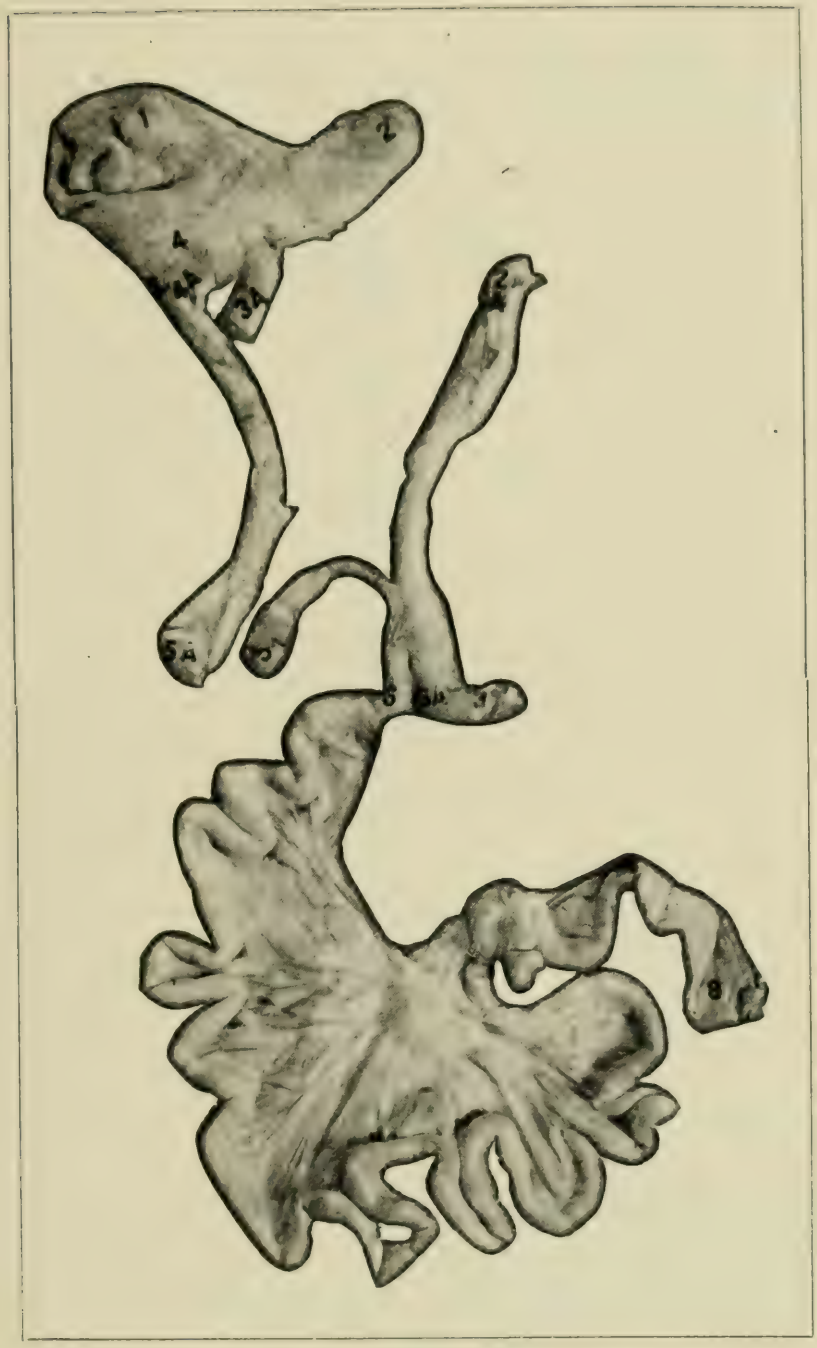

Fig. 7.—1, cardiac end of stomach; 2, pyloric end of stomach; 2 *A*, aboral pyloric end; 3, oral end of jejunum; 3 *A*, aboral end of jejunum; 4, 4 *A*, gastrojejunum; 5, 5 *A*, obstructed ileojejunum; 6, 6 *A*, duodenal jejunum anastomosis; 7, pancreas; 8, sigmoid.

corroboration, however, is necessary to prove that this test tube product is identical with the vital lethal product of acute obstruction.

A true lethal line or point of maximum obstructive toxicity exists in the second portion of the duodenum,

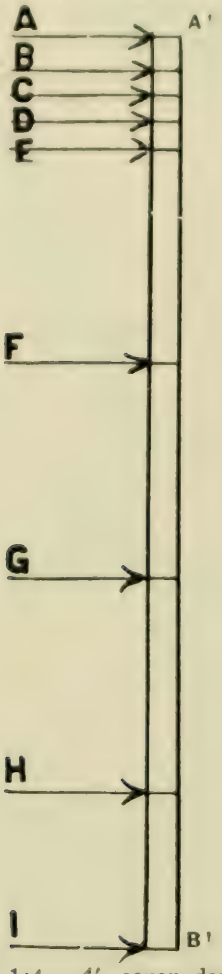

Fig. 8.—Length of life, 1:4. *A'*, seven days' esophageal obstruction, B', twenty-eight days' rectal obstruction.

oral and aboral to which, obstructive death occurs in a definite mathematical ratio.

The lethal agent is probably of biochemical origin similar to parathyroid or other endocrine secretions, interference with which causes death.

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COLONIC INFECTIONS

SOME EARLY OBSERVED UNCLASSIFIED TYPES

JEROME MORLEY LYNCH, M.D.
W. LANDRAM McFARLAND, M.D.
AND
JOHN W. DRAPER, M.D.

NEW YORK

COLONIC INFECTIONS

SOME RARELY OBSERVED UNCLASSIFIED TYPES *

JEROME MORLEY LYNCH, M.D.
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NEW YORK

In our experimental work on the vertebrates we have noted certain fundamental principles which have a bearing on the surgery of the gastro-intestinal tract, and particularly on the subject under discussion.

It is demonstrable that the rate of progress of intestinal contents is directly proportionate to their toxicity. To illustrate, the course through the duodenum and oral part of the jejunum is the most rapid of any, and the toxicity of these parts is the greatest. Long ago Roger demonstrated a parallelism between the toxicity and digestive power of the intestine. We believe that it exists, and that it is an important part of the bodily protective mechanism. Moreover as regards the intestinal flora, are not these inversely proportional, both in number and in virulence, to the digestive activity? Again, as we have already stated,[1] the acid reaction which we have frequently demonstrated to be present in the terminal ileum is a further factor undoubtedly protective in character. Evidently the hydrochloric acid of the stomach has a similar function.

Inherent in every organism is its power of protection, equally well developed against attack, either from without or from within. A thorough knowledge and a sympathetic interpretation of these fundamental pro-

* Read before the Section on Obstetrics, Gynecology and Abdominal Surgery at the Sixty-Seventh Annual Session of the American Medical Association, Detroit, June, 1916.

* From the Clinic of Rectal and Colonic Diseases, Polyclinic Medical School and Hospital, from the Laboratory of the Polyclinic Hospital, and from the Laboratory of Surgical Research, New York University.

1. Lynch and Draper: Contribution to the Surgical Physiology of the Colon, Ann. Surg., 1915, lxii, 441.

tective properties seems to us of paramount importance in interpreting alimentary disease.

We have further found it useful to recognize nature's division of the alimentary canal into the segments which are protected by the physiologic barriers or sphincters under control of the involuntary nervous system. To these we have applied the generic terms cephalad, central, and caudad segments. This division has been extremely helpful to us, because it conduces to a study of the entire canal as a unit, and if our observations have taught anything, they have clearly demonstrated that of all the systems in the body none has been studied and treated more disjointedly than the alimentary canal. Thus we have long since put aside all considerations of isolated parts of the canal based on the anatomic divisions, having found it much more productive to seek an interpretation of aberrant conditions in terms of physiologic rather than morphologic units. By this process of reasoning we have reached several important conclusions.

As Sweet says,[2] working hypotheses are necessary to surgical progress. The only hope of progress is to search along the lines indicated by physiologic hypotheses. Looking at the alimentary canal, then, in its entirety and studying its pathologic physiology from a standpoint of physiologic sphincter segmentation, one notices that digestion is a segmental process, and is confined to the central segment. The oral segment is preparatory. The aboral is excretory.

As one would expect from these facts, inflammatory lesions are most frequent in the caudad segment, in which the opportunities for trauma are greatest, owing to the character of the material; to the presence of great quantities of bacteria, and to the indisputable fact that the protective elements already noted as inversely proportional to the digestive powers are least.

Focussing our attention more directly on the area of the intestine under special consideration in this paper, we first invite your attention to the ileocolonic sphincter. There are many inherited misconceptions in medicine; not the least is that the ileum is separated from the colon by a mechanical valve. Up to a short time ago our faith in the digestive function of the

2. Sweet: Intestinal Obstruction, Ann. Surg., 1916, lxiii, 720.

stomach was implicit. Experimental and clinical proof has changed our views. Proof from the same source is now abundantly at hand as regards the ileocecal valve. Barsh, Draper and Barber proved that the ureterovesical protective mechanism was a neuromuscular contrivance, rather than a valve. These same principles apply to the ileocecal sphincter. Elliott and the authors have shown that this mechanism can be controlled by the injection of epinephrin. We have performed injections on many persons presenting ileocecal insufficiency, as demonstrated by the Roentgen rays, and have shown that 10 minims of epinephrin is sufficient to control the leak, which later reappears. This fact may be of use in establishing a differential diagnosis between leakage due to loss of internal secretory or sympathetic tone and mechanical interference with the closure of the sphincter.

Another physiologic factor which has direct bearing on the topic under consideration is the recently described inhibitory center, located, according to Keith and Cunningham, in the terminal ileum. Whether, as suggested by W. J. Mayo, this center may be of such great importance in the syndrome of constipation that its removal may be the chief cause of the improvement which not infrequently follows resection of the terminal ileum or not is a moot question. Of its basic importance, however, there can be no doubt.

With these principles in mind, we have assembled the last twenty-one cases of purulent infection of the colon which have come under our observation in the last four years and which have been treated according to the above principles. Some of those cases were so severe in type and the constitutional conditions were so deplorable that a previous diagnosis of tuberculosis had been made. The most striking example of this type occurred in one of the five cases seen by us in consultation at the Presbyterian Hospital through the courtesy of Drs. Brewer, Carter and Swift, and in one referred by Dr. Isaac Adler.

Case 1.—L. M. was admitted Jan. 1, 1916, complaining of blood in stools, diarrhea, vomiting, abdominal cramps and loss of weight. These symptoms were of seven months' duration, having come on gradually seven months before. The vomiting usually followed the ingestion of food, but without relation to the character of the food. It has persisted at irregular intervals, but has never contained any blood. There

was diarrhea with profuse, watery stools, from five to eight, every twenty-four hours, associated with some polyuria. Blood was not noted in the stools until three weeks before entrance. Painful swelling of the feet and ankles began six months before. The patient could not walk and was confined to the bed for a month, and treated in Mount Sinai Hospital for two weeks. He has had some pain in his hands but they have never been swollen. Dyspnea and orthopnea developed during the six months previous to entrance. Three weeks before the mother noticed some red spots over the anterior surface of the tibiae, which seemed to be tender.

On physical examination the patient was found to be poorly developed and very poorly nourished and appeared chronically ill. He did not appear to be in pain and showed no dyspnea or cyanosis. The skin was pale, smooth, hot and dry. There was no eruption on the chest, but on the anterior surfaces of both legs there were a number of small, rounded, nodular masses, slightly raised and a little tender. The skin over the nodules was reddened, and there was a little areola extending beyond. The tongue was coated somewhat, tonsils cryptic, but not enlarged. Otherwise the head was negative. The superficial lymph nodes on both sides under the angles of the jaw, some in the axillae, the epitrochlears on one side, and both inguinal groups of glands were palpable. The lungs were negative. The heart was slightly enlarged to the left, the sounds rapid, rather poor muscular quality, with a faint systolic murmur at the apex. The abdomen was slightly scaphoid, and moved slightly with respirations, which were chiefly thoracic in character. The abdominal wall was soft. There were no areas of cutaneous hyperesthesia or muscular rigidity or hypersensitiveness. In the right lower quadrant, midway between the umbilicus and anterior, superior spine was felt a compressible, tubular mass, nontender, which slipped under the finger and was thought to be a loop of intestine. The liver and spleen were not palpable, the lower pole of the right kidney palpable. A rectal examination revealed a tag just inside the sphincter, very much like a hemorrhoid.

On Jan. 7, 1916, the patient was seen by Dr. Fordyce, who regarded the skin lesions as probably tuberculous (tuberculids). A specimen taken for pathologic examination showed in frozen section chronic inflammation; the paraffin sections were unsatisfactory, and the sections for tubercle bacilli were negative. The blood cultures were sterile. The stools were negative for typhoid, parasites, blood and tuberculosis. There was much pus but no dysentery bacilli. On January 16 proctoscopic examination by Dr. Carter showed at the anus and extending up from the mucocutaneous junction several granulating ulcers. The sigmoidoscope inserted 18 cm.

showed the mucous membrane granular with numerous areas of ulceration, which bled readily. A diagnosis was made of tubercular ulcerative sigmoiditis and proctitis.

A blood count showed red blood cells 5,700,000, hemoglobin 80 per cent., white blood cells 22,200, polymorphonuclears 62 per cent., lymphocytes 32 per cent. On January 5 the white blood cells had been 26,800, polymorphonuclears 88 per cent., and lymphocytes 12 per cent.

Two Widal tests were made which showed in 1 to 20, good clumping; 1 to 40, slight clumping, and in 1 to 80, no clumping. The von Pirquet was very faintly positive.

On January 20 the white blood cells were 16,000, polymorphonuclears 64 per cent., and lymphocytes 28 per cent. The urine was negative. The patient was seen by Dr. Brewer, who believed that the case was hopeless from a surgical standpoint, and not until operation was insisted on by Dr. Carter, who had seen some patients improve markedly on ileostomy, followed by irrigations of the colon, did he consent to do the following operation.

On Feb. 5, 1916, ileostomy was performed by Dr. Brewer. The cecum, ascending colon and transverse colon, as well as the descending and sigmoid colons, were found markedly thickened and the peritoneal surface somewhat roughened. The ileum was quite normal in gross appearance, as was the rest of the small intestine. There were a few enlarged glands near the cecum, which were firm, and one in the meso-appendix was removed for examination.

Procedure: A three inch vertical incision was made over the outer third of the right rectus about the level of the anterior superior spine. Exploration was done, the terminal ileum was brought into the wound, and the mesentery opened about 1½ inches from the ileocecal junction. A glass rod was inserted into this opening, and the loop of intestine brought out of the peritoneal cavity. A few interrupted sutures were put through the peritoneum and aponeurosis. The usual appendectomy was done, the stump being inverted. There was an enlarged gland in the meso-appendix which was removed for examination. The gland proved to be a normal lymph gland. A diagnosis of chronic appendicitis was made.

Daily dressings were done, and the colon irrigated with a solution of 1 to 5,000 potassium permanganate. The patient was kept on the roof, and given a liberal diet. His color improved, the skin improved, and he gained strength, but apparently no weight. When he was able to be weighed, four weeks after operation, he weighed 57½ pounds (he had weighed 67 pounds before operation). Irrigations which at first brought away considerable blood and mucus gradually cleared up. After five weeks' feedings of buttermilk, from 4 to 8 ounces were alternated with the irrigations, two or three times daily, and patient gained 22 pounds in six weeks on this procedure. He has rapidly improved in every way,

eats very heartily and is quite active. He now weighs 79¾ pounds. He has had proctoscopic examination by Drs. Carter and Lynch, who now find the mucosa of the rectum and sigmoid quite normal in appearance, and believe that he is in good condition to have the ileostomy closed.

This boy gained 22½ pounds within six weeks after the operation. He was seen by us quite recently, and we advised closing the ileostomy. The restoration of the function is perfect.

Case 2.—A. M., aged 23 years, was first seen September, 1911. The chief complaint at that time was epigastric pain coming on from one to two hours after taking food, and heartburn. Two weeks previously there had been an attack of diarrhea lasting ten days. A gastric analysis made by Dr. Adler approximately six months previously showed a simple hyperacidity. Antacid treatment relieved all symptoms. The bowels, with the exception above noted, were regular, and the urine was normal.

Physical examination made September, 1911, revealed no abnormalities other than an occasional friction sound and an occasional inspiratory crepitant râle over the right apex posteriorly.

The onset of the condition occurred in July, 1912, when a slight amount of blood was noted at stool. About two months later bleeding began again. Examination revealed two fissures radiating forward from the rectum. Rectal examination was negative. Under protargol the fissures healed rapidly, but the bleeding continued. Proctoscopic examination in December, 1912, showed an intensely congested membrane studded with pinpoint ulcers. Mixed treatment internally, combined with silver nitrate irrigations locally, produced diarrhea and augmented the amount of blood passed. In February, 1913, the patient was given a proctoscopic examination again, by a different man, who noted the same pathologic picture, but ordered a bismuth, iodoform, oil irrigation, to be retained all night and a krameria, liquor antisepticus alkalinus irrigation for morning use. For two weeks slight improvement followed this treatment, but then the bleeding began in increased amounts.

Bacteriologic examination of the material showed streptococci of the viridans type and numbers of the *Bacillus coli* group. Dr. Barber inoculated guinea-pigs with some of the material and the pigs died after some weeks. The necropsy which I performed on them was negative.

In order to study the natural repairs in peritoneal and non-peritoneal covered end-to-end anastomosis, the pelvic colon of a dog was drawn up, cut, and anastomosed end to end as far caudad as possible at two different places separated by an interval of 5 cm. This operation was performed Feb. 3, 1914, and on February 16 necropsy was performed. There was

little difference in the lumina of the anastomotic openings. The lower or nonperitoneal-covered was the smaller. The liver, spleen and pancreas were congested. Microscopic sections of the anastomosed areas showed unions by fibrous tissue growing in from stroma, submucosa, and muscularis. There was very slightly increased vascularity of the caudad section (nonperitoneal), or no increase at all.

In order to study the causative agent in hemorrhagic colitis, on March 27, 1914, hemorrhagic material was injected into the rectums, previously curetted, of two guinea-pigs and one rabbit. On April 13, necropsy of one guinea-pig by the bacteriologist showed that the liver was congested, the mesenteric glands enlarged, and the appendix loaded with feces. Cultures made from the glands showed a colon-like organism resembling morphologically the organism regained from the original material injected and previously examined bacteriologically. Further cultural reports are forthcoming. The remaining guinea-pig and rabbit are well and normal to all appearances. On April 3, 1914, the same material was similarly injected into two guinea-pigs and one cat. On the 11th one guinea-pig died. Necropsy showed that the retroperitoneal and mesenteric glands were enlarged. No cultures were taken, but microscopic study was made of the liver, spleen and glands. No destructive changes were discoverable in either structure. There was hyperplasia of the lymph nodes.

Three Wassermann tests of the blood proved negative. A stained smear of the rectal discharge prepared by Miss A. H. M. showed a predominance of encapsulated diplococci, occasionally occurring in chains. The only other bacteria found consisted of large, thick bacilli. An examination of the passages from the bowels showed a gram-positive diplococcus, a gram-negative micrococcus, and several gram-negative bacilli, together with pus and mucus. The analysis at frequent intervals regularly gave normal findings. On March 1, 1913, the hemoglobin was 65 per cent. On March 8, 1913, the hemoglobin was 70 per cent., red blood cells 4,600,000, white blood cells 9,600, polymorphonuclears 76 per cent., lymphocytes 22 per cent., eosinophils 2 per cent.; the systolic blood pressure was 125 mm. of mercury, and the diastolic 90 mm. Moderate poikilocytosis and anisocytosis was present.

On March 22, 1913, the white blood cells were 10,000, polymorphonuclears 74 per cent., lymphocytes 26 per cent. On the 26th a vaginal smear showed occasional large, round diplococci and thick bacilli. March 3 and 7, 5 and 10 million *B. coli* C. were injected. Blood examination on June 10 to 13 by Miss H. A. M. showed hemoglobin 70 per cent., red blood cells 4,800,000, white blood cells 7,200, polymorphonuclears 76 per cent., lymphocytes 24 per cent., and no abnormal cell formation.

These histories are given in full because they are classic examples, the one of an acute type, the other of a chronic type with exacerbations.

Of these twenty-one cases, eleven were definitely acute and ten were chronic, with acute exacerbation. The average age of the patients in the acute group was 26.6 years; of those in the chronic group, 37.7 years. The average duration of the acute type of the disease was 32.3 months; of the chronic, 70 months.

Thus, there are certain types of acute purulent and hemorrhagic inflammations of the colon that cannot be attributed to any specific organism. They are characterized by sudden onset of diarrhea, blood, mucus and pus. Sometimes, as in Mummery's case, which closely resembles some of our own, the pulse was rapid; nearly imperceptible, the temperature 104, and the patient presented a picture of the third week of typhoid. Emaciation is marked and prostration extreme. The stools have a fetid odor and pus is passed in such quantities as to suggest the evacuation of an abscess. The stench of this is overpowering.

In other cases, though the diarrhea is severe and the amount of blood lost is considerable, still the digestive disturbances are slight, suggesting an increased peristalsis in the colon only.

The proctoscopic picture of the acute form is typical. The mucous membrane is edematous and dark red, granular, pebbly or bosselated in appearance. It closely resembles fish spawn, loosely strewn over the surface and the mucous membrane appears to be lifted away from its subjacent structures. There are no definite ulcers, the entire intestine being one confluent ulcer.

As the acuteness diminishes the picture changes. The mucous membrane is less edematous and covered by irregular patches of exudate, which closely resemble macerated skin. Between the patches are irregular oblong ulcers, varying in size and depth, with overhanging edges and worm-eaten bases. As the inflammation abates under treatment the mucous membrane becomes pale, and polygonal areas, separated by an arteriovenous network, give to the bowel a checkerboard appearance. It still retains its granular character and bleeds easily if touched.

Finally the mucous membrane seems to become adherent to the muscular coat and loses that elasticity of motion so characteristic of a normal bowel.

After recovery, the dry, shiny, glassy appearance of atrophy appears. The histopathology is perhaps more variable than the gross pathology and is therefore more difficult to give. It is based in many cases on the examination of small bits of tissue removed with a punch, or to small pieces removed during the operation for colostomy. It is that of an acute inflammation involving a mucous membrane and its subjacent structures. In all cases there has been marked congestion accompanied by edema. Congestion and edema may be limited to the mucosa or submucosa or may involve the entire intestine wall. The mucosa may be covered with an exudate composed of pus cells, bacteria, and inflammatory elements. It may be devoid of glands in case necrosis has progressed, or the inflammatory change may be limited to edema, congestion and accompanying swelling of gland epithelium. In one case the exudate throughout was more marked in the mucous and peritoneal coats. The crypts of Lieberkuehn had entirely disappeared and were replaced by an exudate composed of round cells. The blood vessels were abundant on the free surface and engorged with blood. The submucosa and mucosa had entirely disappeared, their place being taken by the exudative layer, which rested directly on the muscular coat. Round-cell infiltration of varying degrees according to severity of process was of course observed. This may be limited to the mucosa or involve the entire intestine and its peritoneal covering. Lymphatic tissue presented no changes except those produced by adjacent inflammation. Such parts of the plexus of Auerbach and that of Meissner as it has been possible to demonstrate appeared normal. The muscular coats were at times involved in the general reaction and presented the usual appearance under such conditions. In two instances the cecal wall was of tissue-paper thinness though all structures were demonstrable. In one acute case submucous cell groups, simulating tubercles and containing giant cells, were found. The tubercles were in structure like those produced in mesenteric glands by foreign body irritation. Mucopurulent, blood-stained discharges from the lower intestine, so charac-

teristic in these cases, have been repeatedly examined for bacterial and possible infusorial content. The results of these examinations were distinctly disappointing in so far as throwing any light on the etiology of the condition. No unusual forms of bacteria or predominating forms of bacteria were found.

In 50 per cent. of the cases the appendix showed a similar pathology.

In addition to the twenty-one cases critically studied during the past four years, we have incorporated information gleaned from seventy-eight cases of our own and of the late Dr. Tuttle, besides seventy cases collected from the literature. Of the latter, however, very few conformed to the type of infection with which we are dealing, being of the specific type.

Braun,[3] and Neumann and Mayer[4] in their writings have failed to suggest any other parasite than those already named.

Kaufmann,[5] in his study of the specific infections limited to certain segments of the intestine, includes dysentery, both the amebic and the bacillary type, cholera, tuberculosis, syphilis, actinomycosis, anthrax and gonorrheal proctitis (described by Benson,[6] Bel,[7] Couret, Bowman[8] and others).

Schmidt[9] negates Kaufmann's classification and names the inflammatory diseases of the colon according to the segment involved and to the infecting organism.

Aschoff[10] speaks of specific infections under the same headings. He tends to regard the intestinal tract as a whole except when dealing with the appendix and the rectum.

Boas, according to Schmidt, was the first to study and report a well-defined case of ulcerative colitis of indefinite etiology.

Rosenheim[11] writes of a number of cases in which the physical signs, clinical symptoms, and the course of

3. Braun, Max: Die tierischen Parasiten des Menchen, 1908.
4. Neumann, R. O., and Mayer, Martin: Wichtige tierische Parasiten und ihre Ueberträger, 1914.
5. Kaufmann, Eduard: Spezielle pathogenische Anatomie, Ed. 5.
6. Benson, W.: Ztschr. f. Infektionskr., 1908.
7. Bel, G. S., and Couret, M.: Jour. Infect. Dis., 1910, vii, No. 5
8. Bowman, F. B.: The Pathogenesis of the Balantidium Coli, The Journal A. M. A., Dec. 2, 1911, p. 1814.
9. Schmidt, Adolf: Klinik der Darmkrankheiten.
10. Aschoff, Ludwig: Pathologische Anatomie, Ed. 3.
11. Rosenheim, T.: Deutsch. med. Wchnschr., 1908, Nos. 7 and 8; ibid., 1913, No. 21.

disease closely resembles those observed by us. He advances several etiologic theories, change in chemical reaction of content of large intestine, change in activity and pathogenicity of intestinal bacteria, etc. His patients have been as a rule under middle age, ranging from 8 to 40 years, and he has noticed that many of them were deficient in stamina. Young, nervous, and anemic individuals predominated and sex exerted no apparent influence. The pathology, as seen by Rosenheim, is that of a true infection of the mucous membrane, occasionally complicated by infiltration of the intestinal walls and peritonitis. Erosions and especially ulcers were secondary manifestations. The colon was affected in varying extent and intensity. The sigmoid flexure was most commonly involved and anatomic changes were always more marked in this segment. Multiple neuritis, endocarditis, and joint involvement were mentioned among the possible complications. (Three of the authors' cases presented very severe skin infections.) It is interesting to note that in 1908 Rosenheim said: "The severe chronic colonic inflammations here considered are not mentioned in textbooks and only occasionally noted in literature. Clinical pictures belonging to this class are here and there described as ulcerative colitis or dysentery." Zweig[12] understood by ulcerative colitis "every form of intestinal catarrh which, beginning as an acute inflammatory process of the mucous membrane of the large intestine, is eventually productive of ulceration. Ulcers are usually in the rectum and sigmoid, but can extend to the cecum, and vary from lentil size to that of a thaler. Symptoms are those of a general infection with frequent stools containing pus, blood and mucus. The amount of blood may vary from an optically imperceptible quantity, to one or two liters, which latter quantity was lost by one of Zweig's patients. The etiology was a matter of conjecture, but an unrecognized form of bacteria might be responsible. . The change in virulence of *B. coli* should be considered. He observed three cases in which achylia gastrica was well marked, and perhaps the antizymotic action of hydrochloric acid produced an increase in virulence of bacteria of the intestine, acute inflammation with ulceration resulting. As predispos-

12. Zweig, Walter: Arch. f. Verdauungskr., 1907, No. 14.

ing causes he has found diverticula in three cases. Operative procedures mentioned by Zweig were artificial anus at various portions of the colon, intestine junctions and appendicostomy. He advocated measures that assured the intestine absolute rest by complete diversion of the fecal current.

A contribution to the surgical literature of colitis is made by Beck.[13] Though Beck is usually quoted in articles on colitis gravis, the conditions observed by him were secondary to organic disturbance of the intestinal tract, such as carcinoma, and the specific infections, such as tuberculosis, typhoid, etc. The nervous elements were not considered by him as of primary value in colonic inflammations. Ileosigmoidostomy was the operation advocated by Beck and employed by him in six cases. Most comprehensive is the chapter devoted to colitis gravis by Schmidt. This excellent article is well worth reading. Within the last six years isolated cases of colitis gravis have been reported by Baustark,[14] Lindenberg,[15] Albu[16] and others. Albu considers acute ulcerative colitis of doubtful origin very rare. One of his two patients died of intercurrent disease, the other progressed to chronic ulcerative colitis, which Albu thinks is very seldom cured. Lockhart Mummery described some interesting cases of what he termed acute hemorrhagic colitis. Some of these closely resembled those seen by the authors. He performed appendicostomy, but from experience with several cases in which this operation had been done, we feel certain that this operation is inadequate.

In studying the literature, of which the foregoing is an abstract, one is impressed by the multiplicity of names and the hopeless intricacy of the nomenclature; also by the fact that the specific as well as nonspecific forms are grouped under a single head. It is not to be wondered at, considering the newness of the topic and the difficulties under which one labors in isolating the specific cause of the differing dysenteries.

As Herbert Carter has said, he is satisfied that many of the fatal cases with a diagnosis of bowel tuberculosis were in reality of the nonspecific type of infection

13. Beck: Arch. f. klin. Chir., 1904, No. 74.
14. Baustark: Deutsch. med. Wchnschr., 1911, No. 16.
15. Lindenberg: Arch. f. klin. Chir., 1912, No. 99.
16. Albu, A.: Deutsch. med. Wchnschr., 1912, No. 38.

and could have been saved by ileostomy. Case 1 illustrates this. The diagnosis was not always cleared up by the histologic findings, for we have noticed great difference of opinion among experts as to the interpretation of the microscopic change.

One is also impressed by the improper use of nonphysiologic measures. We cannot, for instance, see the indication for an ileosigmoidostomy for acute infections of the colon as practiced by one of the above authors.

There were eleven four plus acute cases. Of these, nine patients were operated on; two refused operation. Of those operated on, three were cured, three are pursuing the same clinical course and are rapidly improving, but sufficient time has not elapsed to place them under the cured cases. Two are improved. One was operated on by a colleague, but succumbed later to hemorrhage from the bowel. An appendicostomy was done. We think that cure might have resulted had an ileostomy been used in its place.

The two who refused operation are improved under treatment, but suffer from acute exacerbation when treatment is discontinued.

Of the patients operated on, two refused major operations (ileostomy), but submitted to appendicostomy. They are pursuing the same course as the two cases medically treated, namely, they have gained rapidly in weight and are apparently well, but from time to time they suffer from acute exacerbation.

We found it necessary in one case of ileostomy to perform a developmental reconstruction of the colon because a multiple segmental polyposis was grafted on the original infection. This case has suggested to us repeatedly the relationship between polyposis and continued inflammation of this type.

Of the three plus or subacute cases, there were nine. Seven were operated on, four having been cured. Three were complicated by diffuse multiple polyposis; although they have gained from 10 to 40 pounds, numerous polyps are present, and we therefore are unable to place them among those definitely cured. Thus we cannot close them, and although all traces of inflammation have subsided, still we feel certain that if we were to turn on the current again, they would undoubtedly have a recrudescence. One of these most

interesting cases our colleague, Dr. Treby Lyon, has already collaborated with us in reporting in an article giving full detail of his own case.[17]

Of the remaining two, the first patient, an aged woman who had been bedridden and unable to recognize her family for more than a year, was mentally restored within a few days after ileostomy, and was able to return to her household duties. Although she finally died one year after the operation, necropsy showed intercurrent renal involvement. The results so far as justification of the operation went, were brilliant. The restoration of this woman's intellect was amazing. The last case, that of a baby of five years' postoperative standing, is quiescent while the ileostomy is open.

Of the remaining two, one was a patient with multiple polyposis, having from sixteen to eighteen mucopurulent, serosanguineous stools daily when she entered the hospital. Under medical treatment she gained in weight, and was having three movements daily when she returned home. We advised her son, a physician, that it would be necessary for her to have an operation to insure cure.

This is a very interesting group, in that many had been incapacitated for years, had had incomplete operations performed and were despondent and pessimistic as far as their chances of recovery were concerned. Four out of the six suffered from stenosis at various levels of the canal and required more than one operation before they were entirely cured. The stenosis was so extensive, in one case involving the descending colon, that end-to-side colosigmoidostomy had to be performed. This patient, who was a fireman on the New York Central Railroad, has gained 40 pounds and is now in perfect health. The fact that he requested to be transferred from an electric to the more strenuous work of coaling the Wolverine is sufficient proof of his capacity for work since his operation.

Another patient of this group has a perfect restoration of function, notwithstanding the fact that she had a very marked stenosis of the rectum and part of the sigmoid, and had to live with a colostomy for two years. After this the inflammation had entirely subsided, the stenosis had spontaneously improved through

17. Lyon, Treby: Ann. Surg., lxii, 441.

fibrolysis; lateral anastomosis was done to prevent any recurrence at the most contracted portion of the stenotic area.

Of the subgroup double plus acute, containing two cases, both were operated on. One is absolutely well; the other is very much improved, having still some stenosis which requires constant medical supervision.

What deductions can be drawn from these twenty-one cases of colonic infection? First, that acute purulent infections of the colon can be cured only by putting the entire involved bowel at rest. Local treatment is indicated in every case and should have a satisfactory trial before surgical measures are instituted. It has the advantage of putting the patient in the best possible position to withstand a surgical operation, because he always improves at least temporarily under proper local measures. The striking improvement after ileostomy is seen in the very acute cases. Especially was this so in the case we saw in consultation with Dr. Carter. The two patients operated on by ourselves and this one operated on by Dr. Brewer prove conclusively that this is the ideal operation when the entire colon is involved.

The old idea that if a stoma were made in the small intestines the patient would lose weight and rapidly decline has been proved to be a fallacy. The gain in weight in every case supports the theory that we have long held that there is an inhibitory center in the lower ileum, the activity of which is accentuated after ileostomy, and even though it sometimes takes weeks or months before this function is fully developed, still it does come eventually, and the majority of patients suffer little more inconvenience than do those who have a stoma in the colon. *The dictum which we laid down in a previous paper, that a stoma, to be efficient, must always be placed oral to the infection, still holds good.*

Of the twenty-one patients, six had appendicostomies, and while these improved temporarily and gained in weight, none is nearer to a cure than are those that have been treated by rectal irrigations. We lay particular stress on this because our friend, Dr. Willy Meyer, has always felt that appendicostomy would have accomplished the same result. Sufficient time has now elapsed to prove this to be erroneous.

A patient was seen by one of us (Lynch) in consultation with Dr. Isaac Adler about three years ago. This patient was of the same type as the patient in the second case cited in this article. We suggested ileostomy at the time, but he refused to consider it. Subsequently Dr. Lilienthal performed appendicostomy, and the patient gained in weight, but has acute exacerbations.

There was one other case which proved exceedingly instructive and further confirmed us in our view that appendicostomy is not the operation in these cases. This was a case (Case H.) of acute infection. We performed an appendicostomy and the patient improved slowly. After six months he developed very large, deep and elongated ulcers in the rectum. We then performed a colostomy. Almost immediately there was a marked improvement in the patient's condition. He gained 30 pounds within a month or two, and within a comparatively short period began to resume his occupation. During all the time he had appendicostomy, though improved, he was still unable to attend to his work. While this patient is not entirely cured, yet in the light of our present knowledge and experience with similar cases we feel sure that he will have a complete restoration of function. We mention this as a further argument in support of our theory that appendicostomy is not sufficient.

Patient B, of the three plus grade, had been sick for six years previous to coming under our care. The mistake had been made in his case of placing a stoma in the middle of the inflammatory area. This patient subsequently was restored to health, but required several operations, and the convalescence was considerably prolonged by the fact that the surgeon who first operated did not appreciate the principles underlying the condition.

Of the twenty-one cases, three were complicated by a multiple polyposis. In one case in which we had performed a previous ileostomy we found it necessary to perform a reconstruction on account of a polyposis limited to the cecum and ascending colon. This patient is absolutely well.

Of the two others, one has improved immensely under local treatment. This was the patient referred to by Dr. Wyeth, but who refused to have ileostomy.

She returned to her home in the South, and is now being cared for by her local family physician. The other had an ileostomy and has gained 40 pounds since the operation, and is a practicing physician in a neighboring state. He suffers no inconvenience; but still having some polyps left, he does not feel that his present symptoms would justify him in risking the radical operation, which would probably mean removal of the entire colon. From observations on this patient we feel sure that there is progressive regression of the polyps since operation.

From this study we have also gleaned some facts which will have an important bearing on the future treatment of strictures, namely, that if a stoma is made oral to the infection in every case, restoration of function will result. This particularly applies to strictures with multiple fistulous openings on the outside. The most brilliant results we have obtained have been in the above-mentioned cases. No attempt should be made to split open the fistulous tracts, as these gradually disappear with the infection, so that when one comes to close the stoma, instead of having an incontinent patient, as we formerly had, there has been complete restoration of function.

In conclusion we may state that purulent infections usually begin as an acute process, and may become subacute or chronic; that the segmental character of many infections suggests diminished tissue resistance due to a change in the vasomotor nerves as an etiologic factor; that active bacterial agents have not as yet been demonstrated, but that these perhaps belong to the normal bacterial flora of the intestinal canal; that a rapid increase in weight is compatible with a stoma in the small bowel; that purulent infections are very often overlooked because there is no definite ulceration. This mistake is caused by the extensive inflammation, for the blood and pus which covers the bowel may easily be supposed to come from some other part of the intestinal canal, and by the fact that the observer is dealing with an acute purulent infection which may be segmental in type. This should be appreciated early because we believe that particularly in the segmental type of infection the best results are obtained by making a stoma early in the disease.

ABSTRACT OF DISCUSSION

Dr. J. W. Draper, New York: I have seen a number of these cases with Dr. Lynch and can corroborate all he has said concerning them. That the involuntary system supplies many nerves to the colon which have their cells in the stellate ganglion accounts for the esoteric stomach symptoms so often associated with colonic disease. Elliott has shown that the thirteenth thoracic ganglion is in most active relation with the ileocolic sphincter. Ileostomy, though not yet in general use, like many other newly applied procedures, is relatively old, having been first done by an Italian twenty years ago. Dr. Lynch, however, was the first to appreciate the value of this operation and to apply it with a specific object in view. Sufficient time has now elapsed to prove its value beyond doubt. Moreover, it is based on sound principles in that it affords physiologic rest to the colon, and because it conforms to the law that a stoma, to be effective, must be oral to the infection. Our statistics have shown that in 50 per cent. of cases of colonic infection the appendix has the same pathology as the colon, suggesting that the original focus was appendicular. Ileostomy has had so immediate an effect on the nervous and mental conditions that we have been inclined to believe it traceable to a direct reflex of unknown character on the glandular secretions of the duodenojejunal epithelium. This hypothesis has derived some support from Barber's proof that the duodenum will dilate and contract in response to certain fixed operative procedures on the caudad ileum.

Dr. Jerome Morley Lynch, New York: I merely wanted to mention the medical treatment because in all these cases, except in the acute, and even in the acute at times, the method is well worth trying. A solution of potassium permanganate 1:5,000 is very helpful. In fact, some of the subacute cases we have been able to cure by using these irrigations of potassium permanganate or a teaspoonful of hydrogen peroxid to 1 quart of water. Medical treatment is worth trial in all cases, but physicians should be careful not to prolong it beyond the point where serious damage to the intestine may result. If it fails, there should be immediate recourse to surgery.

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PIGMENTATION OF THE HIND-GUT

A PATHOLOGIC AND EXPERIMENTAL STUDY

W. LANDRAM McFARLAND, M.D.
Clinical Professor of Bacteriology and Pathology, Polyclinic Hospital
NEW YORK

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W. LANDRAM McFARLAND, M.D.
Clinical Professor of Bacteriology and Pathology, Polyclinic Hospital
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The presentation of a paper based on the observation of a small number of cases must justify itself by dealing with a rare condition or by demonstrating new facts concerning a well known subject. With the advance of intestinal surgery, and the increasing number of "developmental reconstructions" and other operations which involve removal of the cecum and part or all of the first portion of the hind-gut, we are able to note with more frequency a pigmentation or melanosis of the mucosa of both organs. This pigmentation may or may not be transitory; but the rarity of its observation at the necropsy table, and the fact that at times a fading of color may be noted through the proctoscope, lead to the supposition that, in not all cases at least, is it macroscopically permanent.

REVIEW OF LITERATURE

Literature concerning pigmentation of the hind-gut is not particularly voluminous. Virchow,[1] who in 1847 described "an intense black discoloration of the mucosa of the entire intestine" in the case of an individual whose death was caused by pulmonary edema, was probably the first pathologist to report an observation of intestinal pigmentation. In 1867, Williams[2] reported in detail a case which exhibited "black deposits in the large intestine from the presence of mercury." Pitt,[3] in 1891, and Rolleston,[4] in 1892, also

* Read before the Section on Pathology and Physiology at the Sixty-Eighth Annual Session of the American Medical Association, New York, June, 1917.

1. Virchow: Die pathologischen Pigmente, Virchows Arch. f. path. Anat., 1847, **1.**
2. Williams, C. J.: Black Deposits in the Large Intestine from Presence of Mercury, Tr. Path. Soc. London, 1867, **18.**
3. Pitt, Newton: Colon Pigmented Black Throughout with Lead, Tr. Path. Soc. London, 1891, **42.**
4. Rolleston, H. B.: Colon Pigmented from Mercury, Tr. Path. Soc. London, 1892, **43.**

reported cases of intestinal pigmentation due to the presence of lead and mercury, respectively. As, however, the observations of Williams, Pitt, and Rolleston are frankly concerned with exogenous pigments, they would not appear to bear on the form of intestinal pigmentation which is here to be considered. In the same category may also be placed the case described by Grawitz[5] in 1892. Solger,[6] in 1898, presented the first series of observations on pigmentation of the hind-gut. It is interesting to note that Solger describes the individuals from whom he obtained his material as having all been cachectic and over 40 years of age. The clinical diagnoses in the seven cases which came to Solger's notice were various: gastric ulcer, senile marasmus, left side pneumonia, carcinoma of the sigmoid with perforation, and hepatic cirrhosis. In each instance pigment stopped sharply at the ileocecal valve. The color of the pigment varied from brown to brownish black, and the macroscopic and microscopic distribution of pigmented areas corresponded to the description afterward given by Pick. Microscopically, Solger speaks of the pigment as occurring in the form of flakes and granules, and as being confined exclusively to the tunica propria of the intestinal mucosa. He apparently failed to observe the very characteristic pigment cells so strikingly manifest to later observers, though he speaks of pigment masses resembling cells, in adjacent tissue. As bearing on the fixity of intestinal pigment, it is interesting to note Solger's mention of a museum specimen prepared in 1866, which, though it had lost some of its color, still presented the cardinal features of a fresh specimen.

Pick's[7] comprehensive article in 1911 is a pathologic guide-post which all subsequent investigators must heed. He was able to collect the data of eighteen cases. The melanotic pigment, he says, invariably concerns the large intestine, without interruption as far as the anus. It begins midway in the ileocecal valve so that the proximal side of the valve is pigment free while the distal side is melanotic. This contrast between the pigment free small intestine and the pig-

5. Grawitz: Virchow-Hirsch's Jahresberichte der gesammten Medizin, 1892, **1.**

6. Solger, F. B.: Ueber Melanosa der Dickdarmschleimhaut, Inaug. Diss., Greifswald, 1898; Centralbl. f. allg. Path., 1900, **11.**

7. Pick, L.: Ueber die Melanose der Dickdarmschleimhaut, Berl. klin. Wchnschr., 1911, Nos. 19-20.

mented large bowel is very peculiar and characteristic. The pigmentation varies in individual cases, from a dark saturated brown to an intense black; in the latter cases the incised and washed intestine looks as if it had been varnished or brushed with tar. In all cases, including those in which pigmentation became lighter toward the ends of the large bowel, pigmentation of the anal mucosa was always sufficiently pronounced to cause an abnormal coloration evident even on inspection with the unaided eye. Melanosis was limited exclusively to the mucosa, and was accordingly not visible from the side of the serosa. Other changes of the mucosa, aside from an occasional senile atrophy, were absent. Aside from purely accidental findings in individual cases, there were no ulcers, scars, inflammatory residues, or catarrhal proliferations. The histologic integrity of the glandular apparatus and mucous stroma, as well as the peculiar immunity of the solitary nodules against pigmentation, was confirmed by microscopic examination. The term "colitis pigmentosa" was therefore inappropriate for designation of the condition. Melanosis of the colonic mucosa presented such a characteristic postmortem picture that anatomic diagnosis could be rendered at sight, without danger of confusion with other pigmented conditions of the large intestine, as occur in chronic catarrhs, old extravasations, or pseudomelanosis. The pigment, principally contained in cell bodies, was undoubtedly limited to the connective tissue stroma of the mucosa, the epithelium and lymph nodes in the mucosa being entirely free. Pigment was never diffusely distributed or of crystalline composition, but was always amorphous with color varying from grayish brown to yellow. Bulky pigments were shown by the microscope to be proportionately shaped pigment cells. The pigment cells Pick considered as being connective tisue cells from the tunica propria of the mucosa.

Heuck,[8] in pursuing his extensive pigment studies, had the opportunity of examining not only the two pigmented intestines removed at necropsy in Munich, but also some material furnished him from Berlin by Pick. The Munich patients were 40 and 67 years of

8. Heuck, Werner: Pigmentstudien, Beitr. z. path. Anat. u. z. allg. Path. (Ziegler's), 1912, 54.

age, respectively, and both were afflicted with carcinoma. Heuck gives no clinical data. His histopathologic observations coincide with those of Pick.

Henschen and Bergstrand[9] appear to have been unusually fortunate in the number of pigmented intestines which they were able to collect for examination. It is quite striking that from 225 routine necropsies performed in the city of Stockholm, they were able to obtain sixty-five pigmented intestines, whereas Pick found only three in 7,000 necropsies, and Solger, though he had access to a large amount of necropsy material, could collect only seven cases for his dissertation. Henschen and Bergstrand contend that if all intestines removed at necropsy were examined microscopically, the presence of pigment would be more frequently noted. They state, however, that in all their patients over 40 years of age, pigment was macroscopically evident in the large intestine. In several instances the ileum was pigmented in the vicinity of its cecal junction. The submucosa was occasionally involved, as were also the solitary lymph nodes, and in several cases pigmentation of the lymph nodes of the masocolon existed. Persons from whom these tissues were obtained were for the most part over 40 years of age, though some were under 30. Their clinical histories usually indicated senile marasmus, and chronic obstipation was a constant factor.

The most important proctoscopic observations that have come to my attention are those of Dr. J. M. Lynch,[10] who described three cases which he had been able to study. The persons were aged 29, 32, and 51 years, respectively. All gave histories of severe obstipation of long duration, and in each case the mucous membrane was dry and appeared a bluish black, which was more intense in spots. Two of these persons improved under treatment, and macroscopic evidence of pigmentation materially decreased within six months or a year. Lynch[11] devotes a chapter to a description of the macroscopic picture as observed through the proctoscope. There are, he says, "very

9. Henschen and Bergstrand: Studien über die Melanose der Darmschleimhaut, Beitr. z. path. Anat. u. z. allg. Path. (Ziegler's), 1913, **56.**

10. Lynch, J. M.: Unpublished paper, read before the Proctological Society at Atlantic City, 1912.

11. Lynch, J. M.: Diseases of the Rectum and Colon, 1914.

few symptoms connected with this disease. It is nearly always associated with constipation, and most of the cases of general hemachromotosis have been preceded by some intestinal disturbance."

PATHOLOGY

Gross Pathology.—Both the gross pathology and the histopathology of pigmentation of the hind-gut have been so clearly given by Pick that any subsequent description of the tissue changes observed must of necessity follow him closely in detail if not in phraseology. Macroscopic appearance of the intestinal mucosa in pigmentation of the hind-gut not only varies with the amount of pigment present, but is evidently influenced to a certain extent by the manner in which the tissue is handled. In tissue removed at operation, the color is materially affected by congestion which follows clamping, and in three cases here cited pigmentation was revealed only by microscopic examination. This factor may to some extent be responsible for the infrequent recognition of pigmentation of the hind-gut at time of operation and divert such tissue from the laboratory to the furnace of the unscientific hospital. In such portions of the hind-gut as may be observed by means of the proctoscope, the color varies from gray-black to light brown, or it may have the mottled "toad's back" appearance mentioned by Pick. Two specimens of the present series which were removed at operation and included the ileocecal valve, cecum and ascending colon were uniform gray-black or mottled throughout. Pick has described the mucous membrane as being mottled like a toad's back, and noted the following variations in color: "The tint may become a little lighter in diffuse spots of the mucosa, or in an entire segment, passing from a deep black into a lighter shade of brown." He further notes that there may or may not be a failing of melanosis toward the rectum. On these minor points my observations are not entirely in accord with those of Pick. In the one case seen at necropsy there was an even tar-black pigmentation from ileocecal valve to rectum; in the other cases, even shading throughout the specimen. It is natural that the influence of postmortem change should be thought of, but the specimen of this series

was secured within two hours after death, and it is not probable that such a factor would be overlooked by Berlin's most astute pathologist. A cut section of the intestinal wall may show a thin brown or black line corresponding to the mucosa, or the surface may exhibit nothing indicative of pigmentation. There is variation in thickness from that of tissue paper to somewhat more than normal. Extreme thinness is confined to the cecum and is, of course, a condition frequently noted in long standing cases of intestinal stasis. The serosa shows no change. In Case A, the mesenteric glands of the mesocolon were darkened. In Case A, the abdominal organs, as in the cases of Pick and other observers, were free from pigment.

Microscopic Pathology.—When the intestinal wall has markedly thinned, there is, of course, a diminution in the depth of the gland pits; otherwise they appear to maintain their normal depth. The cells lining the glands may be somewhat increased in size, they may present a normal appearance, or they may be somewhat smaller than normal. The goblet cells are neither increased or diminished in number, nor do cells foreign to this layer appear. The connective tissue of the mucosa is not affected except in the very thin intestines, where it appears to have undergone some degree of atrophy. In the connective tissue of the mucosa, between the basement membrane of the gland epithelium and the muscularis of the mucosa, are observed a varying number of pigment cells. These cells may be arranged in a uniform layer and lie close to and follow the basement membrane of the epithelium, or scattered through the stroma of the mucosa. The cells vary in size from 7 to 20 microns and have a single round or oval concentric nucleus. Such pigment as they contain is not uniform either in size of granules or in color. Some cells are gorged with large light or dark brown granules, while others hold dust-fine, saffron-colored particles. There is also a certain amount of free pigment in the form of isolated granules or clumps of granules, though the clumps of granules may be pigment cells so overloaded with pigment as to obscure their cell bodies. The pigment cells resemble morphologically the plasma cell found normally in this locality, though Pick considers them connective tissue cells of the tunica pro-

pria, and Henschen and Bergstrand regard them as several types of the wandering class of connective tissue cells of the stroma of the mucosa. Sections of two ileocecal valves showed pigment to stop at a midpoint in the valve, the ileac side being pigment free. Large numbers of eosinophils may at times be seen in the mucosa, and in Case A an occasional ameboid-looking body was noted, but the character of these bodies could not be determined. The last tissue examined exhibited pigmentation of the distal end of the ileum.

Submucosa: In several cases pigment cells were found in the solitary lymph nodes, and occasionally a cell can be seen beneath the muscularis, which is in contradistinction to the description of Pick, but has been noted by Henschen and Bergstrand. The muscular walls and serosa were free of pigment cells, and neither I nor my colleague, Dr. Jeffries, could note microscopic change worthy of mention other than occasional atrophy. Mesenteric glands: In Case A, pigment cells corresponding in every way with those of the mucosa could be seen. These cells appeared to be principally gathered on one side of the gland in a position probably corresponding to the junction of the afferent duct.

Chemical Examination.—It would be of no avail to chronicle in detail a series of failures. All solvents and dyestuffs which I could think of, or which were suggested by the experiments of others, gave negative results. Hence, if deduction can be drawn from negative results, the pigment, from its resistance, must resemble the melanin group.

NATURE OF THE PIGMENT

The character of the pigment found in intestinal pigmentation is the Scylla, and its etiology the Charybdis, between which no investigators follow the same course, but on which all come to grief with more or less grace. Unfortunately the problem is one which has not as yet received the cooperative attention requisite for its successful solution. Literature on the subject comes from the pens of men who are either pure histopathologists or physiologic chemists, though in some instances they have been a combination of both. Nowhere does there appear to have been concerted investigation by clinician, histopathologist and physi-

ololgic chemist. As the work of physiologic chemists on the subject of the body pigments has been not only extensive, but far from conclusive, it is with great difficulty that essential, but of necessity elementary, details can be culled out and condensed for a paper of this kind. A more elaborate enumeration of body pigments than is here attempted or a more comprehensive exposition of their chemistry is not deemed advisable. To those desiring more light on the subject I recommend the rich bibliography accompanying the article of Heuck.

Pigments relating to intestinal pigmentation fall naturally into two groups—exogenous and endogenous. Of exogenous pigments but little need be said, they being, as a rule, salts of either silver or mercury, easily accounted for in the clinical history of the patient and demonstrated without difficulty by chemical and microchemical methods. Endogenous pigments present a much more difficult problem for consideration, and it is practically impossible to confine such considerations to any specific pigment or group of pigments. E. von Gierke[12] says that one can divide endogenous pigments into two great groups, those derived from blood pigment (hemoglobin pigments) and those formed from other body substances through cell activity (autogenous pigments). If one follows the classification of Heuck, endogenous pigments encountered in the body may be divided into the hemoglobin pigments and the autochthonous pigments. Further subdivision separates the hemoglobin pigments into three groups, malarial pigment, hematoidin and hemosiderin. The autochthonous pigments include the fat-containing abnutzungspigment and the melanin. In contradistinction to the classification of Heuck, and as illustration of the diversity of opinion on the subject of body pigments, may be quoted the following somewhat broad definition by Adami.[13] In the paragraph dealing with "modified hemoglobin," Adami speaks of a succession of modifications of the hemoglobin pigment "hematin," leading to the eventual deposit in tissue of two, or more correctly, three substances, hematoidin, hemosiderin and hemofuscin. Further, Stengel

12. Von Gierke, E., in Aschoff, Ludwig: Pathologische Anatomie, 1911, 1.
13. Adami, J. G.: Principles of Pathology, 1910, 1.

and Fox[14] say that consideration of hematogenous pigment "concerns the deposition of pigments derived from hemoglobin, of which there are two groups, the siderous and the nonsiderous. The chief siderous pigment is hemosiderin, which has, however, many modifications; the nonsiderous pigments are derivatives of hematin-

Fig. 1.—Pigmentation of the ileum: *A, A,* gland; *B, B,* pigment cells; *C,* muscularis mucosa; *D,* submucosa; pigment cells in submucosa. (Photograph by Dr. Wightman.)

hemotoidin, hemafuscin, melanin, etc." Heuck, on the other hand, does not think that hemosiderin is derived from hematoidin, nor does he consider hemofuscin one of the pigments coming from coloring matter of the blood but rather belonging to that class of pig-

14. Stengel and Fox: A Textbook of Pathology, 1915.

ments originating from lipoid substance and in consequence being an abnutzungspigment identical with the lipofuscin of Borst. As to the derivation of melanin or melanins, von Furth, according to Adami, regards them as being developed by the action of intracellular oxidases (tyrosinase) on the aromatic chromogen group of the protein molecule.

As it is not necessary here to regard malarial pigment, the chemical composition of only two of the blood pigments need be considered, following the classification of Heuck. Concerning the exact nature of these pigments and the chemical processes involved in their formation there is much controversy. Their characteristics in general, however, are as follows: Hemotoidin is a red or brownish gold, crystalline or granular substance, dissolved in concentrated sulphuric and nitric acids and distorted by alkalies; its iron reaction is negative. Hemosiderin is a golden yellow to brown, granular or flaky substance, soluble in acids but insoluble in alkalies; its iron reaction is positive. The definition of abnutzungspigmenten or lipoid pigments given by von Gierke is that by such are understood a class of granular, golden brown pigments that give a lipoid reaction. As illustrations he mentions pigment found in heart muscle, liver, seminal vesicles, etc., which may be normally present or occur in diseased tissue. Heuck describes it as a golden brown, flaky substance insoluble in acids or alkalies; its iron reaction is negative, it is always positive to basic dyes and irregularly positive to fat dyes. Hammersten,[15] in writing of melanins, says that there are some forms which are slightly soluble, and others easily soluble, in alkalies. He mentions choroid pigment as an example of sulphur-free melanin. Others mention melanin as a substance containing a minimal amount of iron but a relatively considerable quantity of sulphur. According to Heuck's table, melanin is a substance occurring in the form of brown crystals or flakes; it is insoluble in acids and alkalis and does not take any stains which are used for the identification of abnutzungspigment.

For the identification of pigments, one must consider the morphologic, michrochemical and staining

15. Hammersten, Olaf: A Textbook of Physiological Chemistry, Mandel, 1900.

characteristics. Morphologic characteristics include form and color of pigment substances. Microchemical reactions pertain to solubility in acids and alkalis of varying strengths and at different temperatures which may be applied for a few minutes or allowed to act for several months. Staining characteristics are ascertained by treatment (both before and after tissue has been subjected to the action of acids and alkalis) with the basic dyes, Nile blue and neutral red, and the various dyes for the differentiation of fats such as are mentioned by Schmorl,[16] or in any similar book which deals with chemical and microchemical methods of treating tissues. Summed up, the information one obtains concerning the nature of pigments found within the intestinal wall is based principally on three factors, namely, the solubility of the pigment, its iron content, and its ability to take dyestuffs both before and after treatment with acids, alikalies and other chemical substances.

THEORIES CONCERNIG INTESTINAL PIGMENTATION

Limiting this matter to the views of those men who have had the most extensive opportunities for observation of pigmentation of the hind-gut, it is necessary to consider only the opinions of Solger, Pick, Heuck, Henschen and Bergstrand, and Lynch.

Solger appears to have been influenced to a marked extent by the location of the pigment, which he noted as confined exclusively to the tunica propria of the mucosa, the solitary follicles being spared. Although the reactions for iron yielded no very clear results, he considered it necessary, on the basis of the microscopic picture, to assume that the pigment was derived from blood chromatin, especially on account of the resemblance of the pigment deposits to the granular cells observed in the surrounding bloody deposits. Topographic relation of the pigment deposits corresponded with the vascular distribution, more particularly of the small veins. Hence the assumption of stasis in these vessels as a probable cause of pigment formation, though why pigment should show a predilection for the mucosa of the large intestine was not clear.

Pick agrees with Solger as to the distribution of pigment. He, however, noted that it was for the most

16. Schmorl, G.: Untersuchungsmethoden, 1914.

part contained within cell bodies, and on this is based the hypothesis of his theory of pigment production. By microchemical tests Pick was able to exclude iron from the composition of intestinal pigment, but the presence of iron and a not inconsiderable quantity of sulphur was indicated by michrochemical examinations. According to his experiments, the pigment did not appear to be a blood derivative in its chemical properties but to belong rather to the class of true melanins. The melanins of melanosis of the large intestine originate, according to Pick, from the aromatic albumin-disintegration products of the contents of the large intestine (indol, skatol), under the influence of an oxidative ferment, resembling tyrosinase, produced by the connective tissue cells of the mucosa. The capacity for production of this ferment is apparently individual. Indol and skatol are transformed into true melanin, in the connective tissue cells, by way of absorption in the mucosa. This interpretation renders intelligible the otherwise inexplicable limitation of the disease to the large intestine, on the one hand, and to the mucosa with its connective tissue cells, on the other.

Heuck agrees with Solger as to the pigment location and notes, as did Pick, the pigment cells. He considers the condition a true melanosis, and was able in one instance to examine an intestine which exhibited both true melanosis and pseudomelanosis. The pigment he assumes to be "propigment" between true melanin and lipofuscin, though perhaps more closely allied to the latter. It is, as he thinks, a fat pigment normally present in the intestine and increased in quantity through the action of some unknown agent. Why it should be confined to the large intestine, or as to the nature of the pigment cells, he expresses no opinion.

Henschen and Bergstrand consider the pigment to be between a true melanin and abnutzungspigment. They do not agree with the foregoing observers regarding either the limitation of pigment to the large intestine or to the mucosa of the large intestine. In one or two cases noted by them, pigment was found not only in the solitary follicles but also in the glands of the mesocolon. Pick's theory of pigment formation by connective tissue cells of the tunica propria does

not appeal to them as a tenable one. Chronic obstipation being an almost invariable symptom, they regard it as an important etiologic factor. Their supposition is that on the hypothesis of absorption or elimination the eitology of the condition will eventually be worked out.

The theory of Lynch is interesting not only from its variance with those before considered, but because it is the result of deductions drawn from a study of the literature on the subject up to the article of Heuck, combined with opportunity for observation of the living tissue. Lynch, who prefers the term "hemachromatosis" for the designation of intestinal pigmentation, says he is inclined to think that "hemachromatosis is of bacterial origin; that the extent of the disease is dependent upon the severity of the infection; that the probable source of infection is the intestinal tract, possibly starting as an intestinal putrefaction; that this putrefaction lowers the vitality of the tissues, and thereby the cells of the mucous membrane lose their protective properties; consequently bacteria find ready access to the portal circulation. As a result of this, the chromogenic function of the liver is interfered with, and the liver becomes surfeited with pigment and is not capable of abstracting iron from the hemoglobin, with the result that an excessive amount of pigment is circulating in the blood. Further, the cells of the intestine probably have a selective action for these pigments, and as a consequence they are deposited in the tissue, etc. These pigments may or may not give a reaction for iron."

ETIOLOGY OF INTESTINAL PIGMENTATION

The theory of Solger, in view of subsequent researches by Pick, Heuck, Henschen and Bergstrand, hardly appears to merit consideration. Plausible as at first seem the hypotheses of Pick, they will hardly bear analysis. It is well known that indol (Combe[17]) is produced in the small intestine, and although Pick was without doubt aware of this fact, he must, to make his contention of the limitation of pigment to the hind-gut plausible, assume indol to be an exclusive product of the large intestine. That indol is not an important etiologic factor is indicated by the rarity of

17. Combe, A.: Autointoxication, States, 1908.

pigmentation in the terminal portion of the ileum where indol and skatol are produced in large quantities. Henschen and Bergstrand are not able to understand, and with reason, why, even if the first part of Pick's theory were correct, he should assume a connective tissue cell of the tunica propria to be elected for the complicated metabolic process of pigment making. They contend that not a single cell, but several cells of the wandering type of connective tissue cell, are the ones in which pigment is seen. Their supposition is based on variation in the shape of the cell bodies and on the presence of more than one nucleus in some cells. Neither Pick nor I have been able to note other than mononucleated pigment cells, nor could any variation in the form of cell bodies be considered due to other than distortion by pigment granules.

Concerning the nature of pigment, opinion does not diverge as widely as would seem apparent at first glance. With the exception of Lynch, all agree that it does not appear to be a blood pigment. Pick, Heuck, Henschen and Bergstrand agree that it resembles a melanin, and Heuck and Henschen and Bergstrand consider it of the abnutzungs class between melanin and fat-containing pigment. Heuck thinks that it resembles more the latter. In this status it will probably remain until new or more refined methods of chemical analysis can be applied to this particular problem.

There is some degree of satisfaction in the contemplation of conclusions regarding the nature of intestinal pigment. Unfortunately, no so much comfort can be derived from theories concerning its etiology. When one considers the problem, it resolves itself into the following questions: What is the nature of the pigment; what produces it; why is the pigment confined principally to the mucosa of the hindgut; why is the pigment contained principally in cells; why is chronic obstipation an almost invariable accompaniment of pigmentation? Concerning the first question there is nothing to add to the exhaustive analyses of Heuck and Henschen and Bergstrand, and that the pigment substance belongs to a group between the true melanins and the fat-containing pigments appears conclusive. That a ferment is active in pigment production is in accord with the theory of Pick and not entirely at variance

with the opinions of Henschen and Bergstrand, who incline toward an absorption or excretion theory. In considering absorption and secretion as factors, it is, so far as our present knowledge of the function of the hind-gut is concerned, reasonable to assume that absorption plays a more important rôle than secretion.

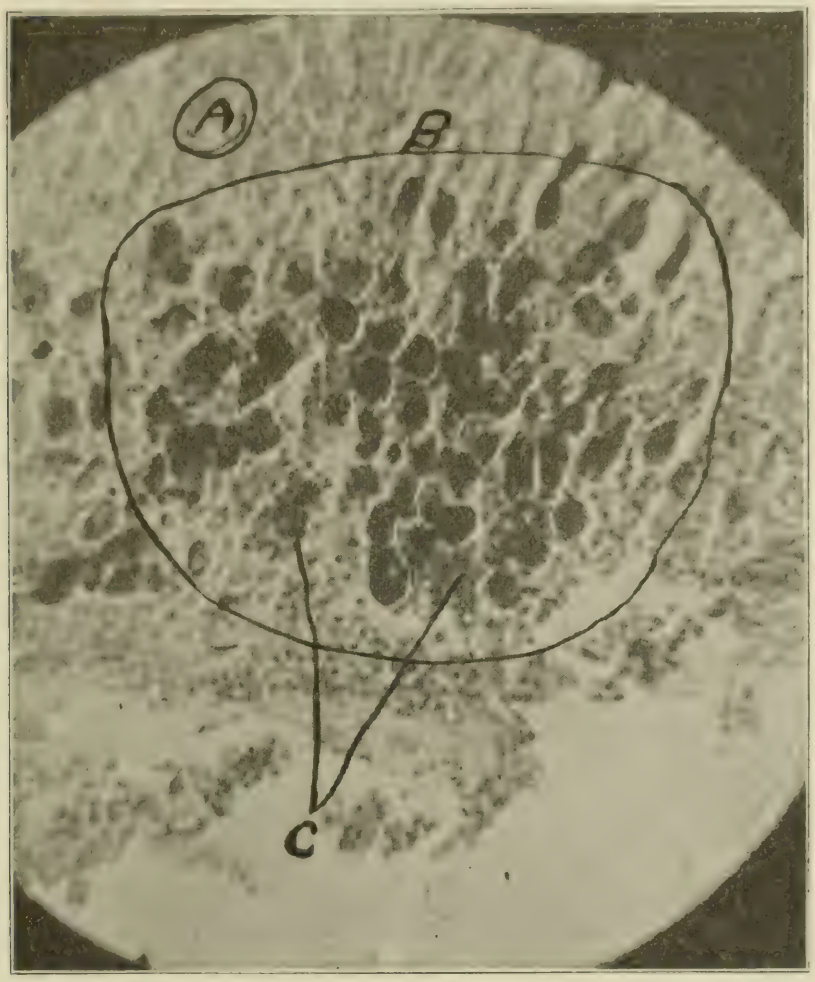

Fig. 2.—Pigmentation of gland of mesocolon: *A*, normal tissue; *B*, pigment cells; *C*, granular nature of pigment. (Photograph by Dr. Wightman.)

It must not be forgotten, however, that though the physiologists tell us that secretions from the hind-gut contain no distinctive enzymes and are composed principally of water, it has been clearly demonstrated by Draper[18] and others that under abnormal conditions

18. Draper, J. W. (Maury): Am. Jour. Med. Sc., 1909; Experimental Intestinal Obstruction, The Journal A. M. A., Oct. 21, 1911, p. 1338.

intestinal mucosa is capable of assuming utterly foreign secretory functions. In support of the absorption factor is the possible action of a variety of decomposition products from putrefactive processes which are accentuated by chronic obstipation. These processes, while usually pronounced in the cecum and hind-gut, may, under certain conditions, be also present in the terminal portion of the ileum. That the substance responsible for the production of pigment in the hind-gut is related in a measure to the so-called tyrosinase, is, in view of the proved nature of intestinal pigment, a not illogical conclusion. The fact that the condition is principally confined to the large intestine supports the assumption that conditions for the production of the tyrosinase-like body are most favorable in that locality. I believe that putrefaction of the contents of the cecum and hind-gut, so invariably an accompaniment of chronic intestinal stasis, is the most important contributing factor. This assumption is based not only on the fact that chronic obstipation is almost without exception observed in individuals whose colons exhibit pigmentation, but also on the statement of Lynch that he had noted a diminution of the optically visible pigment to be coincident with relief of chronic obstipation, and, in consequence, permanent acceleration of the fecal current. I further consider it probable that the pigment-producing ferment is formed principally in the cecum, and that pigment is manufactured by such intestinal mucosa as comes into contact with and absorbs this ferment. Henschen and Bergstrand have shown that part of the ileum may be pigmented, and I have examined two such tissues. Both intestines were removed from individuals that had numerous peritoneal adhesions which confined the distal portion of the ileum in such a manner that stagnation of the fecal current took place to a degree usually confined to the cecum and hind-gut.

Involvement of the cecal half of the ileocecal valve would further strengthen the view that only such mucosa as comes into contact with the pigment-forming ferment will be found to contain pigment. It does not, however, seem probable that this ferment has an intracellular action. It is more probable that it acts on the intercellular substance, of which

there is a comparative abundance in this locality. Such an assumption in a measure accords with the contention of Heuck that we are merely observing an increase of a normally present pigment. From the position of the vast majority of pigment cells it would appear that the ferment acts with rapidity on the first intercellular substance which it encounters after passing the basement membrane. In support of this theory it must be remembered that in the mucosa of the cecum and hind-gut we are not dealing with as highly specialized tissue as that of the liver or of the kidney, but with a tissue whose even passive function has been considered by some as anatomically and physiologically nonessential. As the cecal and colonic mucosas are practically passive walls through which fluids pass, it is more probable that the action of the pigment-producing ferment is on intercellular substances and fluids and not on intracellular substance of any cell or group of cells. The variation in pigment building capacity mentioned by Pick should depend more on duration and intensity of stasis than on difference of individual property to produce pigment-forming enzyme. This is supported by the statements of Henschen and Bergstrand regarding the number of pigmented intestines they encountered in individuals past 40, and by my experience with intestines removed because of chronic intestinal stasis.

Pigment cells are, in my opinion, plasma cells which have acquired visible phagocytic properties. These cells are found in considerable numbers in the stroma of the mucosa; and the cells studied appeared to be morphogically nearer the plasma cell than any other found in the locality. By arrangement of the pigment-containing cells, it would appear that the plasma cells attempt to follow the action of the white cells, which become phagocytes, and to form a protecting wall against further invasion by pigment-producing enzyme, in addition to removing the pigment. Were it possible to follow microscopically the change accompanying permanent acceleration of the fecal current, one could no doubt observe, coincident with decrease of pigment-forming enzymes, a gradual assimilation of pigment granules, as suggested by the experience of Lynch. Migratory properties of the plasma cell carry it to different parts of the connective tissue stroma, and at times to and beyond the muscularis. Those

pigment cells seen in the solitary follicles and in lymph nodes of the mesocolon may be accounted for by the migratory properties of the cell or by the effort of the lymphatic system at removal of waste products.

The theory of Lynch is so at variance with that of other writers that it must be considered apart. It should be of material interest to the reader because of the unusual opportunity for the clinical observation on which it is partially based. I, however, cannot consistently reconcile Lynch's idea of the effect of bacterial infection with the number of nonpigmented but severely infected hind-guts which I have had the privilege of examining for him. Furthermore, it is difficult to understand why a selective action for intestinal pigments should be conferred almost uniformly on cells of the connective tissue stroma of the hind-gut.

REPORT OF CASES

SERVICE OF DR. LYNCH

CASE 1.—Mrs. M., aged 45, had had obstipation for ten years. An operation for developmental reconstruction was performed. Tissue examination revealed pigmentation confined to the mucosa of the hind-gut. The solitary nodules were pigment free. There was no change in other intestinal walls.

CASE 2.—Mrs. O., aged 50, exhibited symptoms which Dr. Lynch associates with pigmentation of the hind-gut. There was prolonged constipation, toxemia, urine at times free from indican, and blood in the stools. Proctoscopic examination revealed ocher-colored pigment extending from the anus to the sigmoid. Tissue examination of bit snipped through the proctoscope revealed pigmentation of the mucosa. The appendix exhibited pigmentation of the mucosa.

SERVICE OF DR. DRAPER

CASE 3.—Mrs. R., aged 44, had severe hemicrania averaging fifty a year, together with severe congenital constipation. An operation for developmental reconstruction was performed. Tissue examination revealed pigmentation confined to the mucosa. The lymph nodes were free. There was pigmentation of the cecal half of the iliac valve. There was no change in the muscle walls.

CASE 4.—Mrs. B., aged 34, had mild mental obsessions and marked depression, with severe congenital constipation. An operation for developmental reconstruction was performed. Tissue examination revealed no pigmentation of the ileum. The cecal half of the ileocecal valve was pigmented. There

was pigmentation of the mucosa of the cecum and the hind-gut. Solitary follicles were pigment free. There was no change in the muscle walls. The lymph nodes of the mesocolon were pigment free.

Case 5.—Mrs. R., aged 55, had chronic constipation for twenty years. An operation for developmental reconstruction was performed. Tissue examination revealed pigmentation of the mucosa only. There was no change in the muscle walls.

Case 6.—Mr. A., aged 60, had profound toxemia. Obstipation had existed for twenty years. An operation for developmental reconstruction was performed. Tissue examination revealed pigmentation of the terminal portion of the ileum and the entire hind-gut. Pigment involved the solitary follicles as well as the mucosa, extended into the submucosa, and was to be found in the lymph nodes of the mesocolon. There was marked atrophy of the muscle walls.

SERVICE OF DR. BAINBRIDGE

Case 7.—Mr. M., aged 36, was always constipated. Colectomy was performed. Tissue examination revealed the ileum pigment free. Pigment was confined to the mucosa of the cecum and hind-gut. There was some atrophy of the muscle walls. As an interesting side light on the toxicity of cecal contents in these cases a cubic centimeter of such, from this case, was injected into the peritoneal cavity of a 250 gm. guinea-pig and caused his death in two hours, the symptoms being those of profound toxemia.

SERVICE OF DR. MEEKER

Case 8.—Mrs. W., aged 42, was troubled with prolonged constipation, etc. Colectomy was performed. Tissue examination revealed profuse pigmentation of the mucosa of the terminal portion of the ileum; also pigment in the solitary follicles and the submucosa.

Three other pigmented intestines are not mentioned in this group because of insufficient clinical data. Of the twelve intestines examined after operation for chronic intestinal stasis, eleven were pigmented. Not including appendixes, we have examined 206 intestinal tissues in our laboratory in the past five years. The foregoing eleven were the only pigmented ones which came to our notice.

COMMENT

It would appear that pigmentation of the hind-gut is a condition dependent on chronic intestinal stasis rather than incident to it. That it is a result, and not

a primary contributing cause of obstipation, is indicated by consideration of clinical data in conjunction with histologic findings in tissue obtained both at necropsy and from the operating table. The influence of pigment, after formation, on the normal physiologic function of the hind-gut is, as are most phases of this problem, a matter on which one is compelled to theorize because of inability to establish facts. Physiology of the hind-gut does not brilliantly illumine the pages of standard textbooks. Other than that the hind-gut serves as a connecting link between the small intestine and rectum and that it absorbs to a certain extent, and secretes a watery enzyme-free fluid, there is but little information pertaining to its functions. That both absorptive and secretory functions should bear directly on the degree of obstipation is understood when one takes into consideration their influence on consistency of fecal mass, lubrication of the intestinal mucosa, and effect on bacterial action. It is, of course, impossible to more than conjecture how materially normal functions of the mucosa are retarded by the presence of pigment. A study, however, of the position of many of the pigment cells would indicate that their interference must be a considerable one. So characteristic was the position of the majority of the cells to Solger, that, noting how they followed the peripheral line of vessels, he attributed pigmentation to circulatory disturbances.

If one recalls for a moment the normal histology of the mucosa of the cecum and hind-gut, he will remember that it is roughly as follows: (*a*) a single layer of columnar epithelial cells resting on a basement membrane; (*b*) connective tissue stroma containing central arteries, veins, lymphatic stem and nerves, with fine branches spreading from the central vessels and anastomosing directly beneath the basement membrane; (*c*) muscularis mucosa composed of a thin layer of muscle fibers separating the mucosa from the submucosa. With this histologic picture in mind, it must be conceded that a foreign substance in greater or less abundance when interposed between anastomosing branches of terminal blood vessels and between or in lymph spaces, mechanically at least, interferes with

the normal performance of the functions of these parts.

If secretions are diminished there is a coincident loss of moisture to the fecal mass and defective lubrication of the mucous membrane. This has been graphically described by Lynch in his protoscopic picture of a dry mucous membrane covered with sticky fecal masses. If absorption is retarded, fats which would otherwise pass through the intestinal wall remain within the cavity and both promote and accelerate bacterial decomposition. On the other hand, however, with retarded absorption, there would be less fluid withdrawn from the fecal mass, though this might be a feature of small importance, owing to the turbidity of the fecal current and the consequent extended period during which absorption can take place.

In both the pigmented and nonpigmented cecum and adjacent hind-gut, during chronic intestinal stasis, there appears first to occur a congestion and edema of the mucosa, accompanied by congestion manifest in all blood vessels throughout the several intestinal walls. Following this phase, if the condition persists, there occurs a very slow but progressive atrophy not only of the mucosa but of all walls of the intestine. (By this I do not wish to convey the impression that atrophy continues until fibrous tissue ultimately replaces the normal structures. In no tissue which I have studied was there an absence of any of the normal coats of the intestinal wall, even though they had been extensively thinned out.) Not considering senile atrophy, we may presume these changes to be due, first, to an irritation of the mucosa which may be either chemical or mechanical and is probably both. After the preliminary irritation, there begins a gradual overdistention followed by loss of tonicity through constant stretching, and disturbance of circulation from pressure of gut content and compression by gut walls. It is more logical to attribute such changes to the causes mentioned than to suppose them to be due to the presence of pigment in the mucosa, though the possibility of a toxic element derived from pigment is within the bounds of speculation.

CONCLUSIONS

If the foregoing premises are correct, it is possible to draw the following conclusions:

1. In true melanosis of the hind-gut, the pigment is not derived from blood pigment, but is a substance between true melanin and fat pigment.

2. This pigment is probably formed by an enzyme which, manufactured by the intestinal contents, acts on the intercellular substance of the stroma of the intestinal mucosa.

3. Pigment-containing cells are derived from plasma cells of the stroma of the intestinal mucosa.

4. Intestinal pigment is primarily an accompaniment and not a cause of chronic obstipation.

5. The clinical significance of intestinal pigmentation concerns the duration and intensity of obstipation, and, while a contributing influence in established obstipation, is not an initial etiologic factor.

I wish to thank Dr. Jerome M. Lynch for many helpful suggestions, Dr. Orrin S. Wightman for the excellent photomicrographs, and Miss Evelyn Bartel for the skilful preparation of a number of interesting sections.

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The Protective or Esoteric Symptoms of the Alimentary Canal With Special Reference to Acute Inflammation of the Colon.

By

JEROME M. LYNCH, M. D.,

and

JOHN W. DRAPER, M. D.,

New York, N. Y.

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THE PROTECTIVE OR ESOTERIC SYMPTOMS OF THE ALIMENTARY CANAL WITH SPECIAL REFERENCE TO ACUTE INFLAMMATION OF THE COLON.*

By JEROME M. LYNCH, M. D., and JOHN W. DRAPER, M. D., New York, N. Y.

It is true that there are many striking analogies between the beginning and the end of the alimentary canal. This is even more marked in some quadrupeds than in man, but its incidence is neither to be doubted nor overlooked, for in the future study of these apparently remote phenomena lies all the hope of progressive therapeusis.

Surgical physiology explains many of these analogies—the lack of digestive activities; the characteristics of the motilities; the sphincteric action, both in systole and in diastole; the common tendency to hereditary variation in form,—but there is one factor in which the analogy strikingly fails: the stomach gives freely of subjective symptoms; the colon does not.

Wm. Mayo has well likened the stomach to a central telephone exchange to which distress signals are sent out from all parts of the body. Most of these, it is true, are appendicular, many are cystic, renal or duodenal in origin,

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From the Laboratory of Surgical Research, New York University, and from the Clinic of Colonic and Rectal Diseases, N. Y. Polyclinic School and Hospital.

but a moiety deserving of careful consideration certainly come from the colon itself.

Now, if we pause to consider why this is so,—and is not the "why" in medicine that which is the most alluring,—do we not rightly seek for the explanation among our prehistoric ancestral records? More and more it is to the fundamental truths of heredity and evolution, of biology and its allied branches, that medicine is successfully turning for an interpretation of facts which were else barren of explanation.

Gradually, as man's progenitors arose from an unspecialized unicellular being to a highly specialized multicellular vertebrated creature, it is self-evident that his evolutionary development was wholly dependent upon food. Very early, therefore, it became an established rule that food should be taken only at periods of greatest advantage to the individual, rather than at times when the bodily resources were needed for functions other than those of digestion, as, for example, to destroy parasitic enemies; to repair the body after injury, or to protect it from further aggression. Hence, it is that the filled stomach empties as the first natural therapeutic step after any trauma, be that from without or within, and that degrees of trauma produce proportionate degrees of nausea or vomiting in the human species.

Now, while thinking along these lines, is it not interesting to consider why the innervation of the colon differs from that of the rest of the canal? It is, of course, familiar to us all that the vagus terminates at the ileo-cecal valve, while the sympathetic supplies the entire canal. Even if a plausible explanation of

this is to be found on embryological grounds, are there not just as plausible reasons for believing that the omission of the colon by the vagus is due to the simple fact that it is unnecessary to the organ? And this may be so even in the presence of certain sacral nerves said to furnish vagus impulses. One can hardly study the problem without inclining a little to the Lamarkian hypothesis that structures have arisen in response to the needs of the organism.

However this may be, it is the fact that, although similar in many functions, the stomach and colon are dissimilar in innervation and in their capacity to transmit subjective symptoms. Hence, the stomach is often erroneously blamed and treated for a lesion which exists in the colon, and reflex symptoms veil the true location of disease. Such symptoms are esoteric.

Is it not interesting, incidentally, that one so rarely sees actual morbid processes, either cancer or inflammation, in that portion of the bowel which really does the digestive work? For digestion occurs only in the small gut. The stomach and colon are but storehouses,—the one preparing food for digestion, the other for elimination. This assertion is based upon the consideration of food digestion alone, the important relation of the stomach and cecum to metabolism and to the far reaching matters of enzyme interaction and internal secretion, being entirely outside of this field. Emphatically, absence of digestive action in both stomach and colon by no means presupposes uselessness to the general body economy.

To recapitulate: Every one is well aware

that while the sympathetic supplies the entire canal, the vagus stops short at the ileo-cecal valve. What does not seem to be so universally known, however, is that almost without exception, subjective symptoms are referred to the stomach, whether the lesion is located there or not. Therefore, the stomach has been from time immemorial the object of much medication and in recent years of much questionable surgical therapeusis. But objective studies of the canal have done much to alter the viewpoint and to improve our perspective. Statistics show that out of every two thousand patients applying for treatment because of stomach symptoms, only two hundred, or just ten per cent., have actual lesions of that organ. In 90 per cent. the definite pathology is remote.

Being surgeons, we are naturally concerned with the recognition and therapeusis of diseases the lesions of which are visible, either microscopically or to the naked eye, rather than with those hypothetical lesions frequently referred to the stomach by gastro-enterologists. Since they are invisible as to pathology, and because of their disappearance after the exciting cause is removed, we are forced to consider them in most instances diagnostic symptoms only, rather than entities worthy of treatment. Nor is this view at all inconsistent with the most recent objective findings, those notably of Symthies being particularly in point. For without peradventure, and after a study of many thousand individuals he has shown that the usually accepted so-called medical diseases of the stomach, if actually extant as entities, are exceedingly rare. How very important a knowledge of Symthies work is to

the profession at large, and how great will be the gain when at last the laity, now growing wiser to such matters, at last grasps the fundamental truth that "indigestion" and "dyspepsia" are almost never symptoms of stomach trouble, but often the first signs of disease elsewhere.

It is our purpose to show that of these remote stimuli which come to the stomach, the colon furnishes many. Indigestion is very often the first symptom of colonic pathology. Take, for example, the so-called mucous colitis, a term loosely used to designate an uncertain pathology, usually of local origin, but withal a very common occurence in the experience of every practitioner,—is it not a fact that the patient is usually more embarrassed by the stomach disturbances than by the actual frequency of the mucoid stools?

Another example is colonic cancer. A patient recently operated upon was treated for six months at one of the leading institutions of the country for "dyspepsia" through the department of gastro-enterology. An adeno-carcinoma, situated within 2 cm. of the anus, was the exciting cause, the stomach being free from disease.

Another whose malignant lesion was located within 4 cm. of the anus underwent four years of stomach treatment because of "pain after eating, eructations and occasional vomiting."

Still another went on to acute intestinal obstruction because of neglected primary carcinoma of the ileo-cecal valve, before the true cause of his "dyspepsia" was discovered.

These cases are cited in no spirit of criticism

but simply to show the great danger of taking anything for granted, particularly as regards stomach symptoms, 90 per cent. of which have a definite basis in other parts of the body. This basis, of course, may be either medical or surgical in nature.

On the other hand, paradoxically, and as though to prove the rule, a man suffering from gastric cancer complained only of symptoms referable to the colon, and was treated for intestinal auto-intoxication, until by chance, and too late, the lesion was discovered.

Perhaps the commonest reflex to the stomach is from a chronic appendix, and it would be wordy to enumerate any cases illustrating this familiar relationship, although in reality this is a colonic manifestation.

Finally, we come to an interesting group of cases of which little has been written and about which still less is known. These may be defined as acute and chronic purulent inflammations of the colon of unknown cause. Almost invariably, the early signs are reflex stomach symptoms. In the literature the term "acute hemorrhagic colitis" has been applied to one of the sub-groups and it is perhaps best described in the words of Lockhart Mummery: "It is an extremely serious and often fatal disease, and there are not yet a sufficient number of cases to permit us to draw reliable conclusions as to its etiology." Of this sub-group we shall speak later.

There are many degrees of inflammation between this sub-group on the one hand and its antithesis, to which we have applied the term *segmental infection*, on the other. In the main group of inflammations at present under con-

sideration, we are purposely omitting the protozoan, except syphilis, which constitutes a group by itself, and is outside of present considerations.

Just because of the lack of cases reported regarding the sub-group referred to as "hemorrhagic colitis," and of the sparsity of the records regarding it, referred to by Mummery, we present herewith the following histories:

Miss M. S., age 23, first seen Sept. 1911. Chief complaint—*epigastric pain coming on one to two hours p. c. and heartburn.* Two weeks previously there had been an attack of diarrhœa. Chemical analysis showed "hyperacidity." Patient put on antacid treatment which relieved all symptoms. Her attending physician was thus lulled into the belief that the stomach manifestation was her fundamental trouble, that it had been diagnosed by the gastric analysis, and that the patient had been cured by the treatment. What a chimerical phantasm this proved to be! In 1912 there was slight hemorrhage at stool. "Anusol suppositories" were believed to be beneficial but the bleeding continued. Finally proctoscopic examination was made and an intensely congested membrane studded with pin point ulcers was revealed. Irrigations of all kind were without avail, the diarrhœa and blood continued. Noteworthy and characteristic of this sub-group was that this girl suffered no pain, showed no rise of temperature, had unusually little tenesmus and showed very little constitutional change.

Ileostomy was then done and after a short time and the usual condensation of the ileac effluent resulting from the physiological adap-

tation of the organ to its new function—a phenomenon to which we will refer later,—the patient was able, with a proper appliance, to be made very comfortable. Indeed, so great was her improvement, and so little her local discomfort, that she danced throughout one entire social season without any of her friends being aware of her condition. The inflammatory reaction having subsided, at the end of about a year, the stoma was closed and at the same time the operation of *developmental reconstruction* was done to remove the deformity of the colon which was rightly looked upon as the prime etiological factor, causing the original inflammation. This view is supported by the fact that the patient has remained well ever since.

Annie G., 31 years old, born in the U. S. We have been granted the privilege of reporting this case through the courtesy of our colleague, Dr. Albert Morrow. During the past ten years this patient underwent a series of operations, one of which was appendectomy. Two years ago, began to pass blood and pus from rectum. She was kept for a time under careful medical treatment but in spite of this her condition rapidly became worse. In this case the stomach symptoms were delayed. There was marked tenderness over the entire colon. Proctoscope showed œdema and ulceration. No amœbae present. Operation by Dr. Morrow, January, 1915. Entire colon thickened and congested and many enlarged mesentery glands were found. *Cecostomy* was done and the bowel irrigated twice daily thereafter. Patient lived six weeks. In spite of heroic medical and surgical therapeusis, including two trans-

fusions, her strength gradually failed, the pus and blood increasing until the end.

A comparison between the pathological findings in these two cases is of great interest and importance. The principal difference histologically is that in the second case the mucous membrane and submucosa is entirely replaced by a layer of exudative material. This rests upon the inner muscular coat. In the first case there is no desquamation of the mucosa. There is intense congestion in the second case while in the first there is hemorrhage into the tissues. In the second case we find round cell infiltration most marked in the neighborhood of the blood vessels. This occurs also in the first specimen, but in addition in the first case we find certain circumscribed areas of round cells somewhat resembling tubercles of tubercular origin. These tubercles contain numerous giant cells. They, however, are not tuberculous. In the second case are some areas composed of blood corpuscles and plasma cells resembling the early stage of abscess formation.

In summing up, the second case presents a picture of an acute condition which has not lasted very long. The first case might perhaps be called both acute and chronic.

Turning now to the opposite extreme, we find, on the other hand, the segmental type of infection is characterized by a very mild reaction, but oddly enough it almost invariably ends in stricture. Is it not seemingly contradictory that the more clinically severe infections rarely do so? Therefore, this is the type which, because of its apparent simplicity, should be recognized early. For, if properly treated, it can be cured often without opera-

tion. The following case is illustrative:

Mrs. S. W., age 37. No children. Wassermann negative. Trouble began in 1911 with *pain in stomach*, fainting, dizziness, eructations of gas and constipation (this is a universal symptom of all forms of acute colonic inflammation). Temporary relief at European Spa. Proctoscopic examination showed segmental ulceration with blood, serum, pus and mucus. Recovery under medical treatment.

Another case (B—n), which might have been cured early, was prolonged for many years by inadequate and unphysiological surgery. Seven and one-half years ago he became constipated, and soon after blood, pus and mucus appeared. Constant stomach trouble from the start. Diarrhœa supervened and patient lost 70 pounds. Saw many doctors, all of whom treated him for "stomach trouble." Finally, the disease was located in the colon and a colostomy was done. But, unfortunately, and as often happens in these cases, the *stoma was placed in the centre of the infected area*, midway in the sigmoid, instead of oral to it. Convalescence from this operation was stormy and later the patient was worse than before, as he naturally had a constant discharge through the stoma in addition to that from the rectum. About a year later he came under our care. Vigorous local treatment was instituted; the inflammation subsided and the X-ray demonstrated an almost complete strictural occlusion of the descending colon. The next consideration was what to do. It was decided to explore and determine whether an ileo-sigmoidostomy or a colo-sigmoidostomy was indicated. This naturally depended upon the extent of the

disease. When the abdomen was opened the transverse colon was found to be healthy and sufficiently mobile to permit of its implantation into the sigmoid aboral to the original stoma. This was necessary because intestinal contents tend to travel via the normal course rather than through lateral stomata.

This brief discussion of cases serves to illustrate the great need of applying fundamental surgical principles to all colonic infections and this pre-supposes an ability to differentiate them.

What are these principles? When the infection is severe and is known to involve the entire colon, an *ileostomy* is the operation of choice. When the infection is mild, local treatment is usually sufficient, but one must know how far to carry local treatment as there is grave danger in being over conservative and, as just cited, permitting stricture development. The *stoma should always be placed oral to the infection.* This can only be determined at time of operation and sometimes it may be necessary to open the bowel before deciding.

Appendicostomy is not a very satisfactory procedure in colonic infections because it permits of constant re-infection from fecal matter and fails to put the parts at rest. Absolute rest is necessary, but the sudden and marked improvement in several of our ileostomy cases has led us to believe that after ilestomy, as after gastro-enterostomy, very important biochemical changes † take place in the epithelial secretions, and which may have quite as much to do with the gain in weight and gen-

†Cited by Patterson, of London.

eral well-being of the patient as the better known factors of rest and re-infection. As the "rest" hypothesis has been in part explained away after gastro-enterostomy, so it no doubt will be after ileostomy. Such beneficial biochemical changes probably do not take place after appendicostomy. One of us has called attention to the elaboration of poisons by the intestinal epithelium, perverted through obstruction, and Whipple believes it to be a proteose.

In infections involving the lower rectum and anus and where stricture already exists with several fistulous openings leading from the stricture to the outside, any surgical procedure other than a colostomy is sure to end disastrously. After a colostomy and with proper local treatment, all inflammation usually subsides; the tracts disappear; the stricture can be dilated and after a time the colostomy may be closed, a perfect functional cure resulting.

This brings us logically, to the therapeusis of stricture. First and foremost, it is very important to differentiate at once between the strictures of syphilitic origin and those due to other causes. For it has been our experience that syphilitic strictures are not amenable to treatment by resection. Autopsy studies have convinced us that it is impossible at operation to determine the true limits of the arterial changes which determine the future patency of the gut. Tissue that grossly appears healthy may show microscopic changes so pronounced as to subsequently result in stricture, for scar formation and contractures are the inevitable outcome of diminished blood supply,—a sort

of compromise by nature for the loss of more valuable cells. Salvarsan and mercurial treatment should of course be instituted but the same principle applies here as in tabes,—the destroyed cells cannot be replaced, although the disease can be arrested. If the segment of infected gut happens to be the ceco-colon, and is not syphilitic, *developmental reconstruction* is unquestionably the operation of choice. This procedure is so named, not to obscure, but to clarify the chaotic nomenclature of these parts. The common term "partial resection" may mean anything from a centimeter to a meter, and in any part of the colon, whereas, developmental reconstruction has a definite limit. *It implies resection of the terminal ileum, cecum and ascending colon.* It is properly called developmental because it places the ileo-colic junction in the position where it is usually found after rotation and in some of the lower vertebrates. We have described this in full in a previous paper.‡

If the whole colon is involved, obviously the indication is to remove the organ or to exclude it from the entire canal by ileostomy. The latter is eminently conservative and in our hands has proved curative. Polyposis, which we consider of inflammatory origin, may require colectomy after ileostomy. There has been a hereditary dread among the profession of intestinal stomata. One often hears men say that death is preferable to a colostomy or ileostomy. This idea is entirely erroneous. After many years of experience we have found that, with

‡Developmental Rec. of the Colon Based on Surgical Phys.

intelligent management, there is comfort and possibility for useful lives if a proper stoma has been made.** The dread of fluid feces constantly pouring over the abdomen, which has been the nightmare of every surgeon, is a myth. Surgical physiology has shown us that farsighted nature has provided for such contingencies and we should be alive to her provisions. We have shown in a previous paper that the inhibitory center situated in the embryological prototype of the colon; the terminal ileum is a wonderful mechanism contributing so to the regulating of the ileac effluent as to quite compensate for the loss of the absorptive function of the colon.

In conclusion, we cannot emphasize too strongly the importance of studying all the inflammatory lesions of the colon from a broad biological standpoint. Such studies reveal that most of the symptoms which we have been treating as disease entities are in reality often only protective symptoms.

What is to be gleaned from this excursion into a rather new field? First, "dyspepsia" often means an inflamed colon, since the stomach frequently speaks for organs which cannot speak for themselves. Second, because of insuperable bacteriological difficulties no definite classification of colonic inflammations has yet been possible. Third, individual cases can be cured by surgery if applied physiologically. Fourth, through pragmatic surgery and a concise study of the cause, the present need for operative intervention upon the colon, as upon

**The case of our colleague, Dr. Lyon, is illustrative. See his remarks "Contribution to the Surg. Phys. of Colon," by Lynch, Draper and Lyon, Annals Surgery, 1915.

other parts of the body, will ultimately cease—through prevention.

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57 *East Fifty-Second Street.*

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THE ADVANCEMENT OF THE ILEOCOLIC SPHINCTER IN SURGICAL CONSTIPATION.[1]

By W. HOWARD BARBER, M. D., New York.

The "ileocecal valve" has recently come into surgical prominence in the effort to arrive at an effectual method of securing relief for certain difficult cases of constipation. Ranking in importance with the uretero vesical and the bilioduodenal "valves," its structure, physiology, and vital nervous connections with the other parts of the alimentary tract emphasize the wisdom of preserving the structure whenever it is possible to do so.

STRUCTURE.

The ileac sphincter resembles the biliary and the ureteral sphincters in the obliquity of the anastomosis and in the relative preponderance of the circular muscular fibers in the immediate proximity of important nodal tissue. The value of the "oblique union" of the ureter with the bladder has been brought out in a previous study on ureteroenteric anastomosis, in which it appeared that any surgical junction of the ureter with the large bowel, to be successful, must approach 1.5 to 2 cm. in length. Coffey, working on the oblique arrangement of the bile duct with the duodenum, came to a similar realization of the value of obliquely joining the ureter with the intestine. In the case of the ureter, too, it has been shown that its continual prostaltic drive is the surest bulwark against ascending infection, but in those instances in which the neuromuscular mechanism is impaired the "valve" remains as a second means of preventing disease higher up. Further analogies have been shown to exist between the ureter and the small bowel in respect to the coordination of the two ends of each when the distal ends of either become partially or completely obstructed. From these and other considerations it appears that there is an especial wisdom in the preservation of the integrity of the "valve" at the end of the small intestine.

Although the ileum typically meets the ascending colon from the left side, variations occasionally occur. Rarely the small gut ap-

[1]From the Laboratory of Experimental Surgery, New York University and Bellevue Hospital Medical College, and from the Department of Gastro-intestinal Surgery, Polyclinic Medical School and Hospital. Presented for publication December 15, 1916.

proaches the anterior surface of the large bowel; recently an instance in which the ilium effected a right-sided anastomosis presented itself. Anterior and lateral anastomoses are probably acquired through rotation of the ascending colon on its longitudinal axis, as was clearly manifested in the tense inflammatory parietocolic membrane of the case above alluded to.

The anatomy of the "valve" is beyond imitation. Like the invagination of the ureter into the urinary bladder, the ileum is only partially inverted into the colon, for the mucus, submucus and longitudinal muscular coats appear in the sphincter and the longitudinal musculature and serous layers remain outside. This arrangement may be maintained in part by the stretched-out longitudinal muscle and in part by the restraining frenula of the segments of the valve on the interior of the cecocolon. The segments or the pouting lips of the extreme end of the ilium are two in number, an upper or horizontal and a lower or oblique one. The patency of the "valve" varies with the condition of the individual —if anesthetized, on the extent of the narcosis. Usually one finger's tip to two fingers can with moderate pressure be inserted into the opening.

PHYSIOLOGY AND NERVOUS CONNECTIONS.

The function of the ileocolic sphincter is not definitely established. It is held that the "valve" regulates the ileac effluent into the colon, or that the sphincter prevents regurgitation of colonic contents from the cecum into the ileum, or that it is adapted to accomplish both of these processes. Certain it is that, with moderate pressure, perhaps 30 percent of enemata pass into the terminal small gut; with increased force of injection, this percentage of regurgitation increases. Based on these findings, the working hypothesis of "insufficiency of the ileocecal valve" has arisen, and on it much supposedly corrective operative work upon the sphincter has been performed. Serial microscopical studies by A. Keith,[1] of London, have revealed nodal tissue in the anterior and posterior portions of the cecal collar about the termination of the ileum, similar to that about the end of the bile duct in the duodenum and to the thickened neuromuscular meshwork described by Bardeleben,[2] to exist about the vesical end of the ureter. The presence of this nervous tissue, which is no doubt to be regarded as a specialization of the myenteric plexus of Auerbach in the immediate proximity of the "valve," establishes for it an important nodal relay in the alimentary tract second only in importance (if any) to the center in the descending portion of the duodenum.

The experimental effects produced by separating this proximal colonic center from the cephalad portions of the alimentary tract are well shown in the dilatation of the duodenum following incom-

plete obstruction of the end-ileum. Mutch,[3] of London, corroborates these findings clinically. Several of our own human cases have shown increased duodenal shadows and have been found at operation to be abnormally "held down" in the ileocecal regions. Case reports comparatively few "ileocecal cases" with recognizable duodenal changes. X-ray studies from the Mayo Clinic[5] have not yet come to associate other than intrinsic duodenal causes with dilatation of the duodenum. Fortunately, Alvarez,[6] working with intestinal segments, has again revealed an absolute interdependence

Fig. 1.—Diagram illustrating removal of terminal ileum, "ileocecal valve," and ascending colon. This is called "hemicolectomy," or by Lynch-and-Draper "reconstruction."

of the upper end of the small gut upon the lower end as far as its intestinal tone is concerned. The important regulatory influence of the proximal colonic center is well shown in dogs after resection of part of the oral colon, with terminal union of the divided ends and with preservation of the ileocolonic sphincter. Similarly human ileostomy cases, as Lynch and MacFarland[7] maintained, do reveal inhibitory control in the reduction of and in the solidification of the contents discharged from the ileac stoma. These observations serve to indicate the significance of the iliocecum as an important tone-relay center. It is unnecessary to refer to the rich lymphatic

connections of the end-ileum which establish it as a vital absorptive medium. Functionally, this junction of the small and the large bowel appears almost indispensable for the welfare of the individual.

SURGICAL CONSTIPATION.

Surgical constipation implies any obstruction, dynamic or adynamic, of the terminal small or of the large intestine in which surgical intervention is indicated. Due to Lane's enthusiasm, interest is particularly manifested of late years in the obscure adynamic obstruction of the colon. As a result, two schools have arisen—

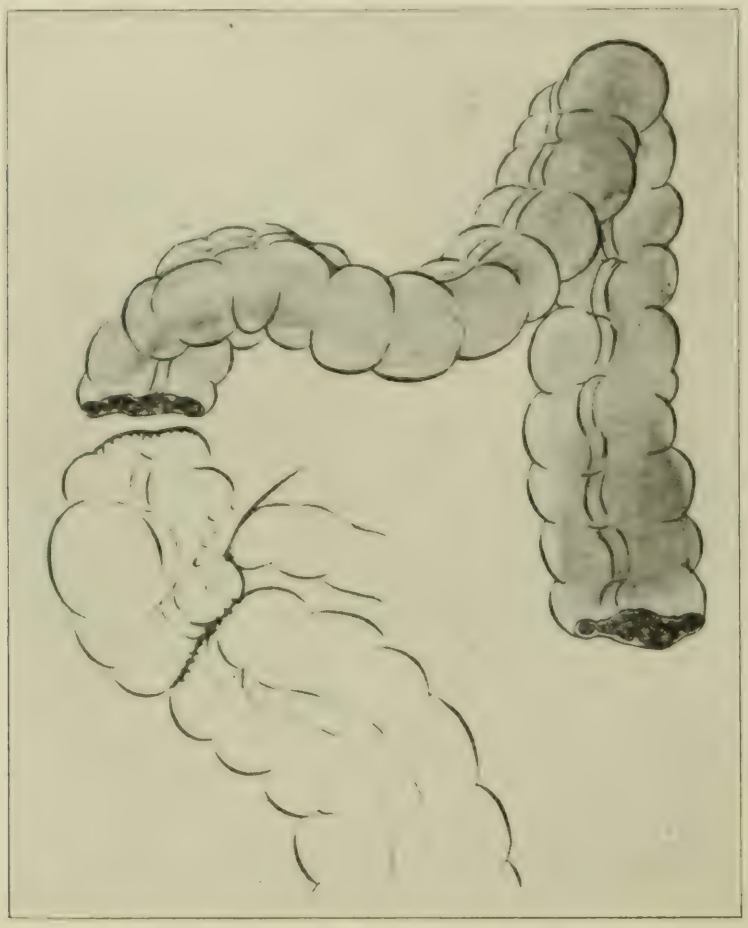

Fig. 2.—Diagram illustrating Lardennois' method of subcecal colectomy. Note portion of large intestine preserved (cecum) and portion removed.

the mechanists, championed by Lane, who ascribe all "stasis" to obstructing bands or kinks, and the laboratory clinicians, represented by Keith, Alvarez, and our own laboratory, who are emphasizing the physiological impairment of the neuromusculature in these difficult intestinal cases. This latter hypothesis is in accordance with what has been said above concerning the "ileocecal valve," explains many of the ill results when the "valve" has been sacrificed, and accounts for the pathological findings in many of the colons resected.

Operations of intestinal resection involving the ileocecum may be divided into three classes as follows:

1. Colectomy, partial or complete, including the sphincter.

2. Colectomy, partial or complete, with the preservation of the ileum, sphincter, and cecum.

3. Colectomy, partial or complete, with the preservation of the ileum and the sphincter only (advancement of the ileocolic sphincter).

In the first group the anastomoses may be terminal, termino-

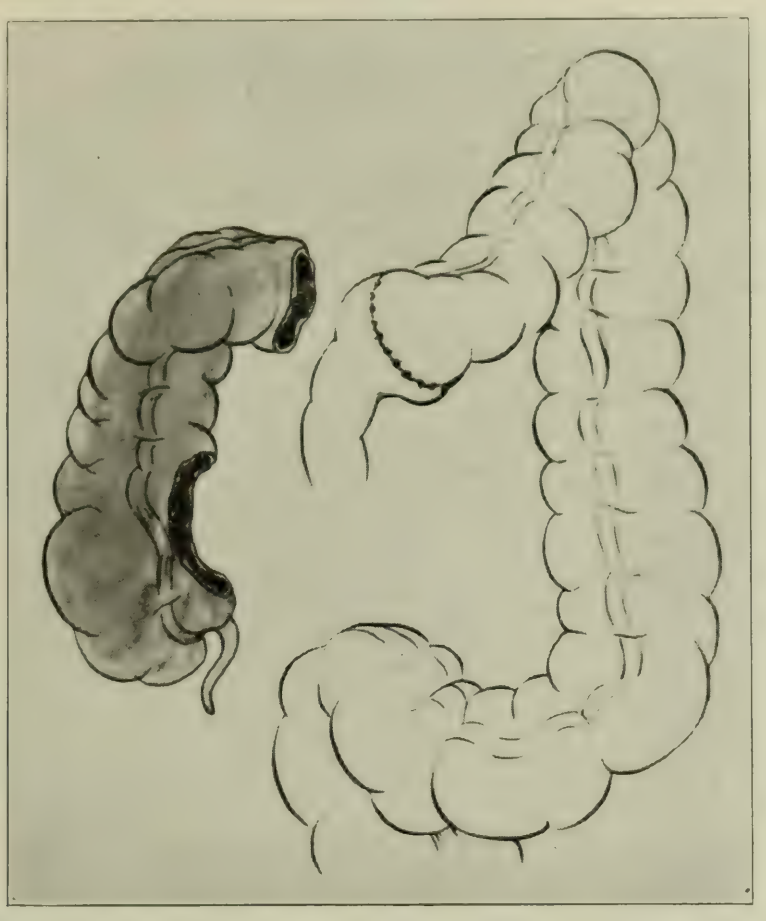

Fig. 3.—Diagram illustrating author's method of advancement of "ileocecal valve," with preservation of terminal ileum and sphincter and removal of cecocolon.

lateral, or lateral, and isoperistaltic or heteroperistaltic. In the latter two groups the anastomoses are of the end-to-end variety. All these unions may be without, in, or within the plane of peritoneal closure. As in gastrointestinal, so it appears in enterocolonic anastomoses that the union which leaves the parts united in the most normal relation with each other is to be preferred. For this reason the segmental resection with terminal union is to be chosen. The disposition of the sutured ends depends on circumstances. Often it appears prudent to leave them loosely attached to the peritoneum behind the wound; occasionally it seems wise to close

the peritoneum about the anastomosis (as in the author's method of enteroureteral anastomosis); but the important point is to leave the operated field accessible in the event that necessity arises to secure relief from gas or from leakage.

The above operative procedures are illustrated in the accompanying illustrations. Fig. 1 represents the method in common practice. It is open to the criticism that it removes more tissue than that directly diseased, including the sphincter. In the after-result it is absolutely impossible to determine in any particular case what results, good or bad, are properly ascribable to the removal of the

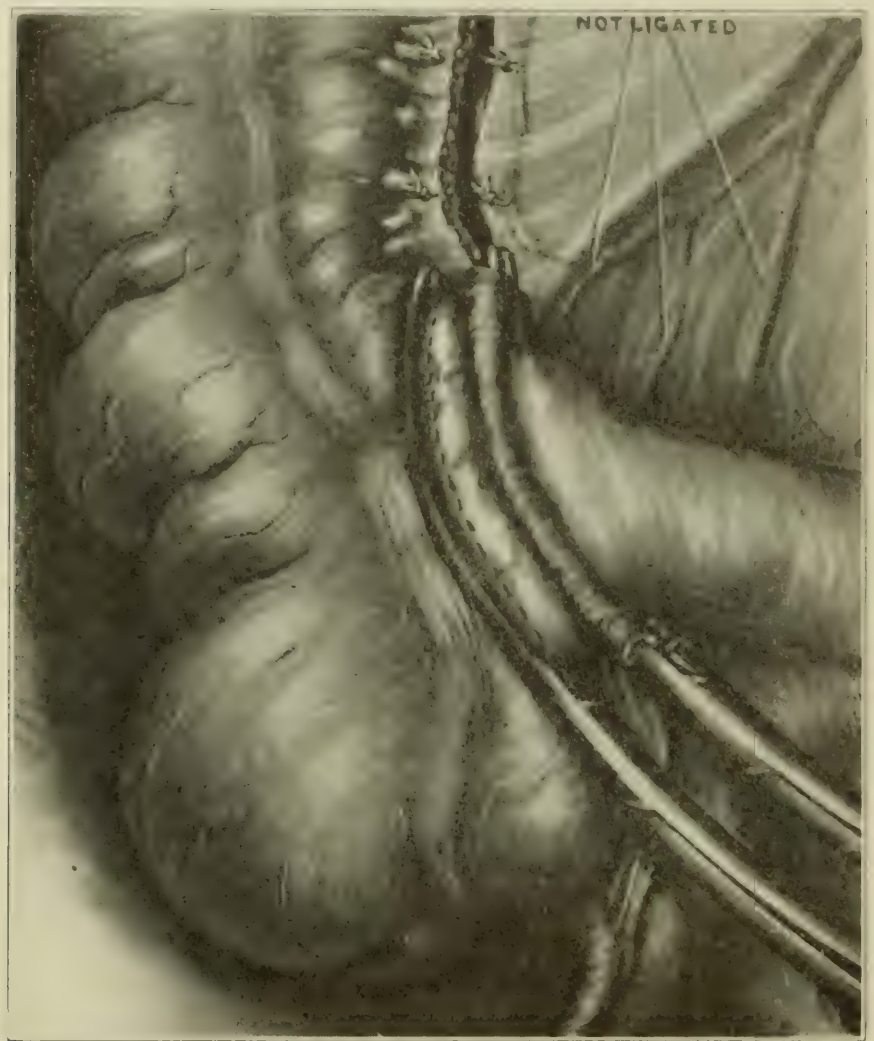

Fig. 4.—Step in advancement of "ileocecal valve," illustrating method of placing clamps, the line of incision distal to the "valve," and the preservation of the ileocolic vessels intact until after resection is completed.

ileum, the "valve," or the more pathological ceco-colon. Fig. 2 depicts the Lardennois method, little known in this country. This operation conserves more normal tissue than the preceding and at the same time some of the supposedly most diseased colon—the cecum. Fig. 3 has been originated by the author to dispose of the objectionable points of both of the above—namely, to conserve the

good tissue, including the sphincter, and dispose of the bad. The "valve" may be *advanced* to any level along the colon, and the collar may be trimmed to fit the cut end of the distal colon.

TECHNIC OF ADVANCEMENT OPERATION.

An incision of ample working size is made through the right rectus. The abdomen is gently explored. Special attention is given the alimentary tract as a unit, bearing in mind what slight disorder

Fig. 5.—One of a series of x-ray pictures taken by Dr. L. T. LeWald, illustrating complete clearance of the small intestine and site of sphincter six weeks after a canine advancement operation.

in one part may upset the balance of other parts of the stomach and intestine. In removing the right colon, the portion to be removed—the cecum, ascending and perhaps the omentum-free end of the transverse colon—is gently drawn out and separated from the remaining abdomen with gauze. Commencing from the lower right side, the peritoneum is divided as closely to the line of colonic reflection as possible. Starting from above and mesially, the same

separation of peritoneum is continued down to the ileocecal vessels. The vessels above the ileocecal vessels are next ligated and divided. The colon is incised between clamps below, as illustrated, and at the plane determined on above. *The ends of the iliocecal vessels are caught and ligated only as they appear in the cecal collar.* Separation of the resected portion is then completed. There should be no difficulty in bringing the divided ends together and suturing. It is important to close the raw surface exposed by the removal of the colon, which is accomplished by suturing the cut edges of peritoneum together over it. Any interval that may be left between the mesocolon and the edge of the mesentery is closed.

CASES OPERATED ON.

The animals experimented on (in all four cases successfully) have had two to three movements daily the first week and by the end of one month two semiformed evacuations a day. The change in their nutrition is about what exists in animals confined within doors.

The following human case gives a corresponding postoperative history: J. P., woman, age 30, married; Italian. Complained of continuous abdominal pain, tenesmus, and the passage of watery mucus twice daily. She retains barium ninety-six hours after meal and shows an enormously dilated ascending colon and hepatic flexure. She had had two previous abdominal operations: one, two years ago, a sigmoidectomy; both without relief. Examinations of blood and urine negative. Her weight is 89½ pounds, dressed. Operation was carried out as above described. At the present time, one month after the removal of the right colon, she is having two soft movements a day, and to date has been free from her abdominal pain.

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A CONSIDERATION OF THE INTESTINAL TOXEMIAS FROM THE STANDPOINT OF PHYSIOLOGICAL SURGERY.*

BY JEROME MORLEY LYNCH, M.D., F.A.C.S.,
AND
JOHN WILLIAM DRAPER, M.D., F.A.C.S.,
NEW YORK.

(From the Clinic of Surgical Gastro-Enterology, New York Polyclinic School and Hospital, and from the Laboratory of Surgical Pathological Physiology, New York University.)

THE alimentary canal is the one single system in the body. All others are bilaterally symmetrical. Why is this so; are there compensations for the apparent deficiency, or does it mean that nature has felt this the oldest of all the systems to be so perfect as to be sufficient to the economy as a single unit? Has this interesting phenomenon any pathological significance? Bichat and others advanced cognate hypotheses a generation ago. Does the length of the canal offer any explanation of its efficiency and what bearing, if any, has the fact that the diameter varies directly with its length? Can any deductions be drawn from the fact that the pars pylorica is well developed long before there is evidence of any fundus? May not priority in origin point to priority in function? Has not the very

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fact of its amazing efficiency a bearing upon the well-known law that as an organism approaches perfection it tends to self destruction?* In its extreme age, in its refinement of function, we may perhaps seek for some of the fundamental causes of its variations from the normal and for the resultant known generally as intestinal toxemia.

Like the many sects in medicine, each one of which sees truth through its own narrow slit, so also has the subject of autointoxication been approached. Some have considered it a mechanical condition pure and simple; some a neuromuscular one; some a disturbance of internal secretions; some as arising from a vagotonic disturbance; some a psychosis; some, like Adami, consider it a subinfection; some, like Combe, a hydrolytic process of bacterial origin. Non-partisan students are at a loss in seeking the truth from among this maze of authoritative statements, for the partisans are clever and their writings are voluminous.

One thing at least is clear, viz., that the causes are either exogenous or endogenous. The factors operating from without, like misplacements, displacements, obstructions, and bacteria which hydrolyze proteins within the lumen are totally separate and distinct from those of a biochemical nature which probably have their origin in the disturbed conditions in the cells of the intestinal epithelium itself, and are properly endogenous.

What part does the modern surgeon play in this complex problem? To our mind a very large and increasingly important one. *The physiological surgeon is the internist of the future.* This view is not held without dissenting voice for the general

*The classic example of this is the extinction of the Irish elk, due to overgrowth of antlers.

conception of the surgeon's place in the therapeusis of the canal, aside from the treatment of acute conditions, is that he may occasionally be of use to remove mechanical obstructions which cause obstipation. Popularly this condition is known as stasis. We hold that this term is an unfortunate one because it implies mechanical rather than biochemical or physiological considerations, which seem to the essayists of far greater importance. This is not a plea against the mechanistic school which plays its important part, but fortunately surgery is no longer divorced from the sciences, having become an integral part of them.* Thus its votaries will give great help in determining the etiology and therapeusis of the non-obstructive, non-static intoxications, in many of which surgical intervention alone avails. This means only that the diagnostician must now think in terms of both medicine and surgery.

The pathology of adolescence begins in utero, and this seems to the essayists one the strongest arguments for eugenics. Whether due to ontogeny or phylogeny needs no further discussion here.

Until birth the child's future is predestined by the forces of nature. In childhood much can be done to correct congenital alimentary defects; at maturity, the individual to a great degree shapes his own career, quite aside from the limitations of his environment. Thus there are three periods—the first, over which we have no control save through eugenics; the second, over which an increasing control will be gained through increasing knowledge of child hygiene and therapeusis; the third, over which control will be gained in direct

*New York University now grants the degree of Ph.D. in surgery.

proportion to the acquisition and diffusion of the truth regarding etiology, diagnosis, and therapeusis. Out of this vast field we have chosen to discuss in detail a few factors relating to the third.

For purpose of comparison we may roughly look upon the stomach as a receptacle which prepares the food for digestion. In action it is analogous to a cement mixer—crushed stone, cement, and water are poured in at one end and without absorption or loss, chyme is dejected at intervals from the other. For is it not in the experience of all to have seen unimpaired digestion proceed in gastrectomized animals or men. It is a specialized morphological adaptation; useful but not essential.

Similarly, as regards the ceco-colon which prepares the food for dejection. Who among us has not seen colectomized men and animals remain in perfect health, all diarrhea being controlled through the assumption of colonic function by it embryological prototype the terminal ileum? Even more significant is the fact that broken health has unquestionably been restored in human beings after partial or complete resection of the colon. It is far from our intent to argue that these organs have no function, for it is well known that along with all other groups of specialized cells, those of the stomach and colon must normally play an important part in balancing metabolism.

To further complicate the problem of surgical diagnosis and therapeusis, there are compensatory properties inherent in the alimentary canal just as truly as in the heart. A resected stomach may in part reform in six months; an ileac segment transplanted into a colon will shortly assume both the size and in a measure the function of the colon, with the exception of anastalsis; a terminal ileum

upon which, by the operation of ileostomy, the function of a colon is suddenly thrown will vicariously assume colonic function both as regards water absorption and fecal storage and dejection; an intestine will thicken oral to an obstruction and in proportion to the load, until, as in the heart, overload begets atonia and dilatation. Thus it is more than ever clear that in the alimentary canal we are dealing with a system which, in part due to asymmetry, in part to extreme antiquity, and to the persistence in it of primordial zymotic reactions long dormant and now superseded by the nervous system, is endowed with many functions, a few of the grosser of which are known, but most of which are utterly unknown. It is a system subject to the utmost variations of form due both to hereditary and to environmental conditions, and which, save the brain, finally is the seat of the most complicated derangements of any part of our bodies. Of the symptoms traceable to this canal one great surgeon has said, "We know so little as to their origin and treatment that we should consider ourselves the fools rather than the neurasthenic patients whom we seek to relieve."

Diagnosis of Adult Conditions.—After all, the diagnosis of adult intestinal toxemias has as its basis the cardinal symptoms diarrhea and constipation. These conditions have been treated empirically from time out of mind, so that it is next to impossible to get either physician or patient to look upon them as symptoms rather than as entities. But progress demands it. As the modern physicist is showing that the supposed elements are really manifestations of a single basic ion, and therefore not in a true sense elemental, so must we modern physicians realize that the ancient disease entities

which we have been taught to believe in are often not elements, but are simply symptomatic, superficial and almost always protective manifestations. They are far more numerous than the sixty-odd old chemical elements, being the variable outward expressions of a fundamental disturbance of metabolic equilibrium and of nature's efforts to heal.

It is the old story of the objective method as opposed to the subjective; of function *vs.* form; of biologic laws opposed to empiricism. It is significant that a true interpretation of symptoms has been the best means of improving therapeusis. We are, at best, only beginning to understand that most symptoms are protective and should be encouraged rather than suppressed until the true cause of the underlying disturbance has been found. Think of the efforts to treat fever faints and inflammatory swellings as though they were enemies instead of friends!

There is no field in all medicine more vivid with the truth of all this than that of the diarrheas. Let us urge that all diarrheas and constipations be looked upon as due to an exogenous cause until proved to be endogenous. Exogenous causes are either congenital or acquired. In our experience failure of fusion and departure from the normal migration of the cecocolon play a more important part than the acquired conditions, for they are transmitted by the same laws of hereditary which govern transmission or other dominant characteristics. The common mesentery which results from non-fusion may permit of 180 degrees mesodorsad rotation upon adventitious bands which often support a cecocolon from the parieties constricting the ascending colon and causing a tadpole-like deformity with intermittent partial obstruction, as

occurred in one of our cases recently. Such bands are doubtless manifestations of nature's efforts to compensate for the hereditary deficiency. No more potent argument is at hand in support of extensive undergraduate study of comparative anatomy and of research surgery on the lower vertebrates than this. For every graduate should know that from a common ancestor we may inherit departures from our conception of the normal; as, for instance, a mobile duodenum or mesogastrium, such as are found in the dog; non-rotation, non-fused mesentery; an herbivorous type of cecum; infantile cecum; megacecum; absence of sigmoid (quadrupeds have no sigmoid according to Henscher & Bergstrand in Ziegler's Beiträge 56, 1913) or of cecum, and a host of other variants, explicable only by heredity. The teaching of these fundamentals seems to us of far greater use than an ingrinding of the pharmacopœia or of descriptive anatomy.

Bayliss and Starlings "law of the intestines" or myenteric reflex is of great importance in the surgical physiology of the alimentary canal. It consists in the production of a relaxation with inhibition of movements aboral to the spot at which a mass of food is collected and an increase of tone together with more powerful contractions oral to the spot, thus moving the contents onward.

The recent papers by Keith recording the presence of hitherto unknown intestinal ganglia also help to explain many things. But there are certain observations which come to the surgical student of the alimentary canal, who studies his cases from a biological standpoint, which seem to us of special interest and which are not as yet widely recorded.

We have for years contended that death from duodenal or jejunal obstruction is due to an inter-

ference with the internal secretory function of the epithelial cells of the gut itself rather than to bacteriotoxic causes This hypothesis is now accepted by most investigators. Now, if this is true of complete obtructions, what diversity of symptoms may not be caused by incomplete obstructions occurring at different levels! Doubtless the complexity of duodenal enzymes or hormones is much greater than that of any other part of the canal, though the subject is far from settled as to details; and this may explain the relative gradation of symptoms and the well-known fact that their intensity varies as the square of the distance from the duodenum or thereabouts. Moreover, what has been accepted for the duodenum may be true also of the colon. This at least affords a working hypothesis to explain the immediate relief from certain types of arthritides, as occurred in one case of our series after developmental reconstruction, and in several reported by Bottomley. We are not sufficiently advanced in a knowledge of the internal secretions to say how important a disturbance of these may be in the colon, nor, indeed whether they exist, but if we are to believe Pick, even the lowly connective-tissue cell of the colon secrets an enzyme called tyrosinase, which has the property of converting aromatic substances into a pigment closely resembling melanin in appearance. Thus Pick would account for pigmentation of the colon.

Furthermore, this matter of internal secretion of the gut may have an important bearing upon the phenomena which we have noted after ileostomy when there occurs a most marked change in the physical well-being of the patient as sudden and as profound as we have noted in the arthritides after colonic reconstruction.

Previously the clinical changes observed after this operation have been explained wholly on the ground that the proteolytic anaerobic bacteria which Combe and his school have credited with so prominent a part in intestinal toxemia were unable to thrive on the acid media of the terminal ileum, and it is on this assumption that Metchnikoff popularized the value of the fermented milks. Here may be another point of similarity between the physiological mechanism at the beginning and end of digestion. The acid ileac chyme discharged into the alkaline cecum may stimulate the outpouring of enzymes in the lower gut as in the upper. What has been proved true of one is perhaps true of the other and there may actually be an internal secretion of the cecocolon which becomes perverted and autotoxic when motility is disturbed.

Next to be considered is what applied surgery can do for intestinal toxemia.

It is accepted that a definite number of patients suffering from the syndrome of intestinal toxemia have been benefited or cured by operation, after other methods have been tried. What are the procedures which have been in general use? First, ileosigmoidostomy. Second, cecosigmoidestomy. Third, appendicostomy. Fourth, ileostomy. Fifth, plication of the cecocolon and repair of the cecal valve. Sixth, total "Colonic exclusion." Seventh, colectomy. Eighth, developmental reconstruction or right ileo-colectomy. The very multiplicity of procedures is in itself a certain index of our ignorance. What can be said of these operations?

Ileosigmoidostomy has undoubtedly benefited a goodly number of cases. But what are its drawbacks and dangers? We have shown in a previous paper that a dominant anastalsis is often the phys-

iological basis for the symptom constipation. All operations must be planned so as to minimize the effects of this symptom of aberrant physiology and if possible to counteract it. The foremost advocates of this operation admit that because of anastalsis in 10 per cent. of cases a subsequent colectomy is a necessary corrective measure. Further, although we may learn to recognize sigmoidal anastalsis before operation, who can say that it may not develop as a result of this operation itself? The technique, therefore, has a much higher mortality than is usually ascribed to it because of these secondary complications, and is rightly falling into disuse.

Cecosigmoidostomy is deficient both theoretically and in practice. Its employment leaves out of consideration the law to which we have referred, viz., that intestinal contents tend to follow the normal direction of the canal, irrespective of lateral stomata. We again wish to emphasize the importance of this law. We have recently demonstrated a vicious circle in five out of six cases. The following case history is illustrative of all:

Patient referred by Dr. Robert M. Brown of Saranac Lake, New York. Cecosigmoidostomy was performed for the relief of intestinal toxemia eighteen months ago by a thoroughly competent surgeon. After the operation the symptoms were aggravated and *x*-ray examination showed that material lay in the distended loops —for an interminable time. This patient was made to realize the severity of secondary operation but expressed the positive conviction that she preferred death to her existing state, being at the time unable to correlate mentally. Indeed the mental symptoms were more serious than the physical. Operation revealed an immensely distended sigmoid and cecocolon, each communicating with the other through a stoma which readily admitted *four fingers*. The technical part of the previous operation had been perfectly performed, but

the functional result was a failure. In order to restore normal conditions it was necessary to resect that portion of the sigmoid containing the stoma, to anastomose the sigmoid, to resect the terminal ileum and the colon as near to the splenic flexure as could be reached. An unusual amount of traverse colon had thus to be sacrificed because it was dilated as a result of the previous operation to the thinness of tissue paper and could hardly have been expected ever to regain proper tone. The ileum was then anastomosed to the extreme left transverse colon in the usual way. Result very satisfactory.

Appendicostomy is safe though insufficient in most cases. One important fact in its favor is that it places the stoma oral to the entire colon. This is in keeping with our observations, viz., that a stoma to be effective must be oral to the infected area.

Ileostomy.—This new procedure first intentionally employed in this country by us has limited and definite indications, but is of proven worth. It was devised and employed by an Italian some twenty years ago. In connection with our observations upon severe colonic infections we will deal with this procedure in a subsequent paper.

Plication of cecocolon may benefit, but it is questionable whether the results are permanent, and this coincides with our animal experimental work. The technical defect may be that the coaptation is peritoneal rather than muscular. We have now under consideration an adaptation of the autolytic pentagonal suture which we have long used experimentally. This introduces the problem of segmental resections, the most important work upon which has been done by W. Howard Barber.

Plication of the Bauhinian sphincter is said to be beneficial. We have had no experience with it; first, because our *x*-rays in the healthy humans show frequent leakage after enema, and, second, because

we have shown experimentally that the mechanical action of all "valves" is of small value compared with the neuromuscular forces about them.

What of the cured developmental reconstruction cases in which the "valve" is excised?

Total colonic exclusion is a new operation, just described by Strauss. It will afford additional opportunities for study and may come to have a place in the operative therapeusis of the future, but its principles are quite at variance with the conclusions reached by us experimentally. and upon human beings twelve years ago.

Colectomy has a place but it is a small one because of the mortality and of the removal of omentum and the terminal colon which is active in elimination. Lardenois, however, demonstrated to us in Paris that it is possible to leave the omentum. Colectomy is indicated in diffuse polyposis, papillomatosis, diverticulitis, and in certain malignant tumors.

Of the many operations which have been suggested that of developmental reconstruction has proved very satisfactory in certain carefully selected cases. The writers have applied this term to the ordinary operation of resection of the terminal ileum, the cecocolon, and the oral part of the transverse colon, because it exactly describes the procedure. The colon is reconstructed to the primitive or developmental type seen in the adult dog, or in the human fetus just following rotation, the great gut beginning in the right hypogastrium, there being no true cecum or ascending colon. We have felt that there may be a definite relationship between the symptomatic improvement in human beings after developmental reconstruction, and the fact that more primitive forms, like that of the dog,

are free from colonic disease. We have called attention to the fact that this last formed portion of the colon is more liable to disease than the older aboral portion. As in the case of other organs which have become diseased and dangerous to the economy this organ, its function destroyed, should be removed.

One word in regard to colonic vaccines. There is this to be said in favor of the vaccine treatment: that it usually helps, it is free from danger, and if an operation becomes necessary subsequently it places the patient in the best possible condition to withstand it. It is valuable postoperatively.

Rectal feeding has long been a satisfying and comforting necromatic rite. It was ancient history when Hippocrates was a boy. Of all the delusions of grandeur ever inherited by the profession this was the most mythical. At last, however, we have arrived at something definite, viz., the use of amino acids. Urinary studies prove this. These final products of protein digestion occur in the blood, dialyze readily, and are the logical postoperative sustaining agent of the future.

One cannot consider the field of colonic surgical therapeusis without being convinced that the future holds out great things. And perhaps the greatest of these is the hope that physiological surgery collaborating with medicine may help us to find the true cause of the toxemia, and with it a cure which will not be operative.

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THE SURGICAL TREATMENT OF INTESTINAL TOXEMIA.*†

By JEROME M. LYNCH, M.D.,
and
JOHN WILLIAM DRAPER, M.D.,
NEW YORK CITY.

IMPRESSED by the striking analogy between the mental attitude of certain members of the medical profession and that of the reactionary element in civic governments we quote from a recent paper by the Earl of Mar in the last *Scottish Review* as follows:

"Nowadays the race is not so much to the strong as it is to the impressionable and nimble of mind. The mind that is destined to succeed in the world must be as open to impression as the oyster is to the sea. Groove must be avoided quite as carefully and scrupulously as the plague. The individual who wishes to compass a prosperous journey through the world must set out with eyes fully skinned. *We must be alive to example and susceptible to change.* We must be prompt to recognize that existing conditions are not necessarily the best that can be devised and that

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† From the Clinic of Surgical Gastro-Enterology, N. Y. Polyclinic Medical School and Hospital, and from the Laboratory of Surgical Research, New York University, N. Y.

a torpid state of mind and habit of body in face of the march of events is the very best passport to failure.

"Born into a world whose pivot is change and decay the man of crystallized ideas is as little sensible of the genius of physical nature as he is of the fluctuations of fate and fortune in the institutions of which he is a part. He imagines that the particular institution to which he belongs is destined to endure for all time in spite of the many solemn warnings addressed to him by history. And, as for understanding the aspirations of those whose viewpoint differs from his own he will have none of it, nor does he wish to acquire it."

How aptly these words from a great lay pen coincide with those of the scholarly Moynihan, who discussing intestinal toxemia says, "nothing is worse than sloth of the imagination."

Equally significant is this quotation from Draper's Intellectual Development of Europe: "Is there an object presented to us which does not bear the mark of ephemeral duration? We fail to find anything that is not undergoing change. Forms are in their nature transitory, law is everlasting."

Why cannot we as a student body take unto ourselves the words of these great teachers and assume an open-minded attitude toward this newer problem of medicine. Surely our history is replete with examples of the fate of those pioneers who found and taught the truth in face of orthodox opposition, and the point for us to face squarely is that even to-day and in our own profession the ultra-conservative rides the saddle while the progressive walks. In our circumscribed sphere we act the parts which we see

others acting in the greater drama of life. Everywhere: in politics or in profession; from the cradle to the grave the immutable law governing human beings; doctors, priests, lawyers, legislators, ordains that all must be either conservative or progressive; reactionary or idealistic.

Let us review this entire question of intestinal toxemia and try to analyze the various theories so far presented. By way of illustrating the antiquity of the subject Stich, in 1853 and no doubt others before him, evidently striving to get an insight upon intestinal toxemia injected feces from the same and from other animals into the rectum and veins in an effort to prove the old and erroneous hypothesis that all evils arose from fecal absorption. Bouchard in '82 showed that feces contained alkaloids and recognized that some were soluble in $CHC1_2$—others in ether. Among the many other students of this subject, Metchinkoff, Roger and Combe stand out prominently. The first championed the bacteriological, the second the bio-chemical, while the third correlated all that had been done and crystallized it into a form of medical treatment. Lane, seeing this work from the viewpoint of a surgeon who in his time was more or less of a mechanic and influenced chiefly by Metchinkoff's theory and presuming that all intoxications were due to a "static" condition, set about to apply his mechanical genius to the restoration of "drainage." Surgeons plunged headlong into this fantastic procedure and regardless of physiological objections proceeded to short-circuit all patients suffering with headache and constipation. Lacking the mechanical genius of Lane, the technic was often defective; lacking his discrimination the diagnosis was often wrong.

What was the result? Lane has been damned and misunderstood, whereas in reality there was much of merit in his viewpoint. After the excitement had died down, Adami in a hypercritical and erudite paper brushed aside much of the previous work; presented his theory of sub-infection and concluded that the importance of the subject had been overestimated. Under the stimulus of Sir A. Wright arose the School of colonic vaccinists. Like many other methods vaccine therapy has great merit as attested by the reports of Satterlee.

After another lull, Kellogg and Case noting an associated insufficiency in a percentage of their cases concluded that they have solved the Mosaic problem of leadership. Now while no one can deny that valvular insufficiency is probably not physiological and that dire results may follow a mixing of the contents, it is probably but one of the many sides to the question of intestinal toxemia and one easily demonstrated. It occurs frequently in subjects seemingly healthy. Maybe they are not. Did Case fully grasp the significance of ileocecal insufficiency. Should people be operated because of it? We doubt it. It seems remarkable that the epoch making paper of Eliott should have been overlooked, for so far as we can see no mention is made of it in any of the papers bearing on the subject which we have read. Relying upon the old anatomical viewpoint; forgetful of the nervous mechanism and its relationship to the internal secretions and encouraged by the radiographs and the apparent cure of numerous patients operated upon for recreation of the valve there arose a school of artificers who forgot or at least failed to weigh the great

truths advanced by Eliott. That these have been supported by Starling, Bayliss, Gaskell and others is proof of their value.

Eliott showed that there is a close relationship between one of the internal secretions, namely, epinephrin and the sympathetic. It is an axiom in physiology that if certain nerves are inhibitory in their action epinephrin increases this inhibition and that if contractor, epinephrin will cause contraction. This internal secretion has therefore, been used very extensively in physiology for the purpose of determining many moot points relating to the three great sphincters of the alimentary canal. By a specially constructed apparatus which registered the contraction and by eliminating all other nerve supply Eliott was able to demonstrate after the injection of epinephrin a very marked contraction of the ileocecal sphincter. He showed conclusively that this contraction was confined to a very limited area beyond which the contraction ceased. What is the clinical significance of this experiment of Eliott's? It would seem to us undoubtedly this: That the flow of chyme from the ileum to the cecum is under the control of a muscle and not of a "valve." Barber and Draper and Braash have shown how extremely limited is the value of the uretero-vesical "valve." It is the same in the gut. But there is a far deeper significance attached to this experiment than would appear from this interpretation alone. May it not be possible that a deficiency of epinephrin is really at the bottom of ileocecal "valvular" insufficiency which itself seems to us a symptom rather than a cause. Whether this internal secretion is inhibited by toxemia or the toxemia results from an inhibition

we are not at present prepared to argue. It will remain for future laboratory experiment to elucidate this problem, but at least this gives us some clue to work upon. On the basis of what has been shown by Bayliss and Starling regarding the activation of the pancreas would not one be justified in assuming that an analogous process may take place in the region of the ileocecal sphincter, namely, that with the advent of the chyme a prosecretion is formed which activates the adrenal and that some deficiency in this process may cause at least a part of the symptoms of toxemia. In any event the train of thought based upon the accepted hypothesis that the hormone bodies preceded the development of the nervous system in the process of evolution and that the vertebrates still retain both systems leads to this conclusion. They are more or less complementary to each other.

It is evidently for future investigation to decide in given individuals whether one or both systems are at fault in ileocecal insufficiency. Closely correlated with this is the well-known clinical fact that spasticity of the internal sphincter muscle results in constipation, and that clinically the correction of a lesion at the anus immediately restores the normal function of the bowel. This is part of the sphincteric system of the alimentary canal and has a control similar to that of the ileocecal sphincter and pylorus, only more complex and difficult to understand. From the observations of Dale and others it would appear that the internal sphincter is composed of two parts, the one is supplied by motor and inhibitory neurons which have travelled out together in the thoracic lumbar outflow and are situated near the muscle; the other, by motor

neurons belonging to the thoraco-lumbar outflow and situated in the inferior mesenteric ganglion and by inhibitory neurons belonging to the sacral outflow. It is probable that the internal sphincter is partly volentary and partly involentary, the volentary fibers bring those derived from the levator ani and supplied by the inferior pudendal.

For this reason we wish to emphasize that in our experience and undoubtedly for the same reasons cited, constipation, which is well-known to result from minor lesions of the rectum, such as fissures, etc., is not the mechanical process which we recently considered it,—resident chiefly in the rectum, the direct result of a tight sphincter—but is due to functional disturbances of all the sphincters and can therefore by x-ray, often be located in the cecum or oral portion of the colon or in the stomach itself. It is thus not the simple problem as we have been taught to look upon it, but a very complex one, far removed from mere mechanics. It can be worked out clinically in the light of modern physiological facts and with the help of the x-ray. We have only cited this to illustrate once more the many sidedness of intestinal toxemia. So much for the neuromuscular viewpoint.

From the bio-chemical viewpoint: To the French scholar and pathologist Roger, professor and director of the laboratories at the University of Paris we owe much to our knowledge regarding the true autointoxications. Roger conforming to the ideal type described by the Earl of Mar, possessing nimbleness of mind and other salient characteristics; presented chemical proof of the poisonous character of the secretions of the epithelium of the duodenum itself many

years ago. This proof simultaneously worked out by the authors has recently been corroborated and elaborated upon by Whipple and others who agree with Roger that certain of the poison causing intestinal toxemia belong to the proteose group. This view has long been held by the writers who have themselves contended that the toxemia of partial or complete intestinal obstructions, particularly of those situated in the oral portion of the tract were much more bio-chemical than bacterial in origin. The only microscopic tissue change after death from this toxemia of epithelial origin is an intense congestion of the capillaries noted chiefly in the terminal colon. We believe this to be frequently the starting point of colonic infections which until now have been studied entirely from a narrow bacteriological viewpoint. May not this injury by the toxins be accountable for the subsequent bacteriological invasion which results in the purulent infection of the colon which in common with others we have described in previous papers.

Roger showed in '08 that the toxicity of the secretions of the stomach was very low, but was increased more than fourfold after acting upon meat. He also showed that the duodenal secretion was infinitely more toxic than that of any other part of the canal. Thus the *toxicity is universally proportionate to the digestive activity of the gut.* The writers have shown by repeated experiment that the duodenum is virtually free from all pathogenic bacterial forms. The organism cannot well exist without the duodenum. The terminal ileum, ceco colon and often the stomach are filled with every conceivable sort of bacterial life. *No digestive process worth naming takes place in these organs.* The

organism can well exist without them. These facts are interesting, instructive and convincing.

What has the bacterial viewpoint of intestinal toxemia to offer? Perhaps the most recent hypothesis is that presented by Underhill who arguing that it is unnecessary to presuppose bacterial activity upon the percursors of the amino acids, presents the view that a further splitting of the amino acids produces the poisons which cause the familiar symptoms. He holds that it is much easier from a clinical standpoint to explain the action of the bacteria upon the simpler end products of the proteins than upon their complicated intermediary products of hydrolysis. There is no doubt in our mind that this suggestion from so eminent an author shall serve to throw valuable light upon this important phase of the subject.

What has the mechanical viewpoint to offer? In a limited percentage of cases the mechanical factor is all-important. We have spoken of the hypothesis regarding the nature of the toxins; chemical, bacterial, etc. The mechanical obstructions when present play an important part in facilitating the entrance of these toxins into the body. That a certain delay of the stream is present in most cases is probably true. That this delay may be caused by physiological disturbances such as those already referred to is also true.

Our experience with the mechanical conditions is as follows: Most of the obstructions of the terminal ileum have been spasmodic—a few have been due to bands,—the only true mechanical obstructions outside of sporadic cases have been those due to "elbow deformity" of the ascending

colon. The frequency with which this occurs; its constancy of position and the persistent tendency to reformation leads us to ascribe to it an embryological origin already discussed by us in a previous paper. The deformity is of course due to the well-known "veil." Other bands of adhesions occur at various levels and are familiar to all. These are evidently the result of local inflammation.

What has applied surgery to offer and what are the procedures that have been in general use?

1. Ileo-sigmoidostomy.
2. Ceco-sigmoidostomy.
3. Repair of "valve."
4. Cecostomy.
5. Plication.
6. Appendicostomy.
7. Total colonic exclusion.
8. Colectomy.
9. Ilesostomy.
10. Developmental reconstruction.

The first three have failed because they are unphysiological. The fourth is unnecessary if the appendix is present. The others have as yet a place in surgery. We are tabulating the results in twenty-eight cases of developmental reconstruction of the colon with results that to date are encouraging.

Summary.

Our experience with these operations is as follows:

Ceco-sigmoidostomy, five cases—a faulty operation.

Appendicostomy, 100 cases. Satisfactory when indicated.

Ileo-sigmoidostomy, five cases. Results unsatisfactory, due to packing of the partially excluded colon.

Colo-sigmoidostomy—very satisfactory.

Ileostomy, twelve cases—very satisfactory in all.

Plication, eight cases—temporarily satisfactory.

Developmental reconstruction, twenty-eight cases—most satisfactory of all when indicated.

Discussion.

Dr. J. W. Draper, New York City, in closing said: Intestinal toxemia is a many sided problem; the tendency in the past has been to consider each of the factors constituting it as entities rather than as fused in a composite picture. Thus the attitude of the profession toward it should be one of open-mindedness. Many theories have been advanced all of which have certain merit; the bacterial, the bio-chemical, the neuromuscular, the mechanical. No branch of progressive medicine illustrates more concisely than this the immeasurable value of animal experimentation and the truth of the statement that abstract findings along experimental lines are always of value even though their application may not be made directly to human beings for a number of years after. Thus the experiments made by the speaker under the direction of Dr. Robert Weir in 1901 which led us to the conclusion that duodenally obstructed animals died from absorption of toxines which were of truly autogenous origin due to perverted activity of the duodenal epithelium itself was for years rightly regarded as having merely an academic interest. Now after fifteen years the applicabil-

ity of these results toward solving the problem of intestinal toxemia in man is only just beginning to be realized. This proof of the dependence of progress of applied surgery upon vertebrate experimental study was one of the most important points in Dr. Snow's paper. The French pathologist, Roger, in 1907, showed that the toxic material was undoubtedly a proteose. His work has been recently corroborated and added to by Whipple. No one has given greater stimulus to students of the problem than Hartwell of New York whose work on the bacterial and water privation relationship to the lethal outcome was valuable. In the speaker's experience the water losses had not been so great after duodenal obstruction ending in death as had occurred after thorough dosing with pylocarpin but not to the point of interfering with the animal's health. The essayist has spoken of the microscopic condition of the organs after death. That is probably not a reliable index because the function probably can be greatly impaired in these acute processes without showing much microscopic change, to wit: glycuronic camphor pairing power of the liver has been shown to be reduced from twenty-five to thirty-five per cent. as a result of intestinal obstruction. The microscope showed no change. Our latest studies show the non-coagulable nitrogen blood content to rise fully fifty per cent. in acute duodenal obstruction. Underhill's recent studies have shown that the action of the bacteria upon the final products of protein hydrolysis rather than upon the primary products may stand in important causative relation to the symptoms of partial or complete intestinal obstruction. It is very significant that if the epithelium is de-

stroyed in a duodenal loop which drains to the outside the animal will live, whereas if such a loop is created the animal will die if the epithelium is left intact.

The problem of ileocecal insufficiency is not by any means as simple as has been supposed. One must consider it from embryological, anatomical, neuromuscular and bio-chemical standpoints. We are dealing with a sphincter, not a valve, a physiological rather than a mechanical mechanism. A differential diagnosis between mechanical and physiological defects at the terminal ileum can therefore probably be made by the injection of epinephrin. The toxicity of the epithelial secretions is directly proportionate to the digestive activity of the gut, the stomach and ceco-colon having no digestive power are correspondingly lacking in toxicity. Physiological surgery is a corrective measure in selected cases. Of all the operations ileostomy and developmental reconstruction have given the best results for the relief of intestinal toxemia.

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DEVELOPMENTAL RECONSTRUCTION OF THE COLON*

ANIMAL RESEARCHES AND CLINICAL REPORT OF TWENTY-NINE HUMAN CASES

BY JOHN WILLIAM DRAPER, M.D.
OF NEW YORK

(From the Laboratory of Surgical Research, New York University, and from the Clinic of Surgical Gastro-enterology, New York Polyclinic School and Hospital.)

COMPARATIVE anatomy sheds an interesting and instructive light upon the development of the human colon. Huntington,[1] discussing primitive types and in particular the terminal straight segment of the canal which is so much shorter in many vertebrates than in man, says: The primitive condition of the intestinal canal may be observed in some members of man's own class, the mammalia, as in certain edentates. Notable among these is the little ant-eater of Brazil. The termination of the duodenum and the bend in the colon mark the two points at which in the primitive scheme the umbilical loop begins and terminates. These two points we can describe as the duodeno-colic neck or isthmus. In the snapping turtle the same condition prevails, namely the duodenum and the colon approach each other very closely at the isthmus and between these points the convolutions of the intestine extend in a wide circle. "We will find this approximation of duodenum and colon a feature which persists throughout all the later developmental stages of the higher vertebrates and has an important bearing on the final arrangement of the intestinal canal in the human adult."

Thus, not only throughout the fish, the turtles and the frogs, but actually in man's own class, we find types in which the adult corresponds in colonic position and limitation of growth to the primitive form.

Anatomy and embryology are not alone in giving important information as to the relative value to the human organism of the right and left sides of the colon. In a paper read before the section on Pathology and Physiology of the American Medical Association, 1914,[2] I have called attention to the relative inactivity of the right or oral colon in the dog as regards the excretion by it of drugs and toxins compared with the activity of the left or aboral portion of the organ. Briefly, it has been noted by us in company with many others, that even in an animal like the dog, in which there is normally no ascending colon and a rudimentary cæcum, there is a vast difference between the excretory activity of the cæcocolonic region and the caudad portion of the organ. In pilocarpine or diphtheria poisoning, or in the toxæmia of

* Read before the American Gastro-enterological Association, Atlantic City, May, 1917.

[1] The Anatomy of the Human Peritoneum and Abdominal Cavity, p. 56.

[2] Draper, J. W.: Studies in Intestinal Obstruction. Journal A. M. A., September 26, 1914, p. 1079.

duodenal obstruction, the oral portion of the colonic mucosa remains normal in color while the aboral assumes a brilliant scarlet.

A third avenue for the approach of this interesting problem of colonic variability is found in clinical study at the operation table on adult human beings. It has long been known to biologists that variations in form attest to recency of origin and instability in function. What thoughtful surgeon is there among us who has not been repeatedly struck with the amazing variations in form on the right side of the colon as contrasted with their absence on the left. The occasional exception to this occurs only in the pelvic colon. Moreover, not as a rule having had opportunity for the study either of embryology or of comparative anatomy, he has been at a loss to comprehend or to make any reasonable interpretation of these variations.

It was only after many years' consideration of these abstract phenomena that my colleague, Jerome Lynch, and I became interested in the possible meaning attached thereto and as to whether any utilitarian application thereof could be made in improving the therapeusis of human disease. Especially after reading Madison Grant's notable book,[3] however, we are more than ever convinced that such utilitarianism, be it in pedagogy, in medicine or in other walks of life, is one of the poorest, if not the very worst, characteristic handed down to us from the Nordic race and of very secondary value as compared with search for the abstract truth. We hold with increasing tenacity that no lasting progress can be made in medicine except by approaching its great problems solely from the standpoint of pure science. As Le Père Felix says: "*Nos progrés sont pleins de la sueur des siécles passés.*"[4] It is in every case an idealist, a Pasteur or a Hunter, who has furnished the framework upon which materialism has built.

In a recent unpublished address before the New York Academy of Medicine the English physiologist, Haldane, said that the modern mechanical methods in physiology had about reached the limit of productivity and that a return would shortly be made to some of the methods previously in vogue, and long since discarded by the mechanistic school, notably the theory of vitalism and its allied branches. We are at the parting of the ways.

From our laboratory and clinical studies we are convinced that our provisional hypothesis regarding the cæcocolon, its relative unimportance and frequent danger to the human economy, based as it was upon biologic premises, is correct. Our clinical data and our experimental studies agree with these premises. The two support each other. Bryant's studies,[5] resulting in a classification of human beings and disease into herbivorous, neutral and carnivorous types, as well as the well-known work upon right colonic resection and exclusion of Bloodgood, Mayo, Ochsner, Satterlee and others, compel the general attention of the profession to the cæcocolon. The far-

[3] The Passing of the Great Race.

[4] Conférences de Notre-Dame de Paris.

[5] Bryant, John: The Carnivorous and Herbivorous Types in Man. Boston Medical and Surgical Journal, September 9, 1915.

FIG. 1.—Dog 174. Control meal showing residue in stomach.

FIG. 2.—Dog 174. After reconstruction end-to-end anastomosis. No delay, but high mortality.

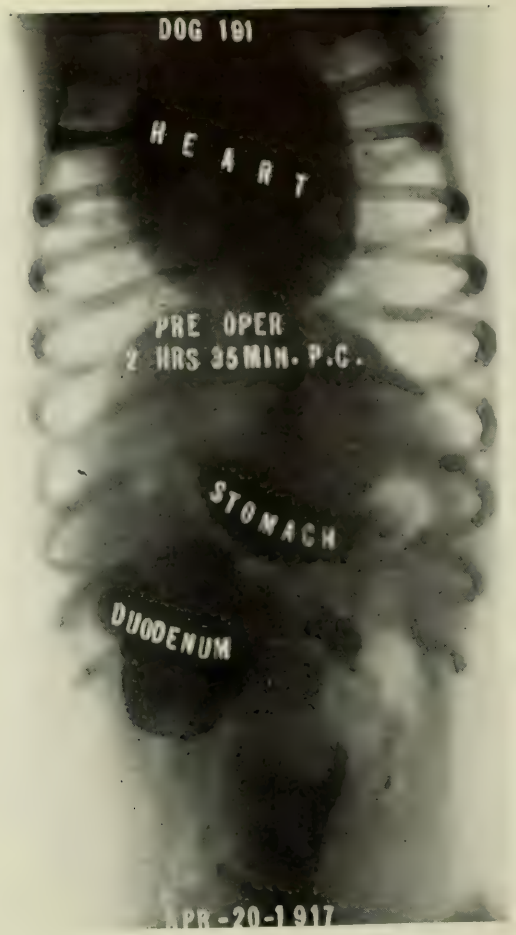

FIG. 3.—Dog 191. Before developmental reconstruction of the colon: end-to-end anastomosis. Note the disproportionate size of the heart shadow in the dog as compared to the human.

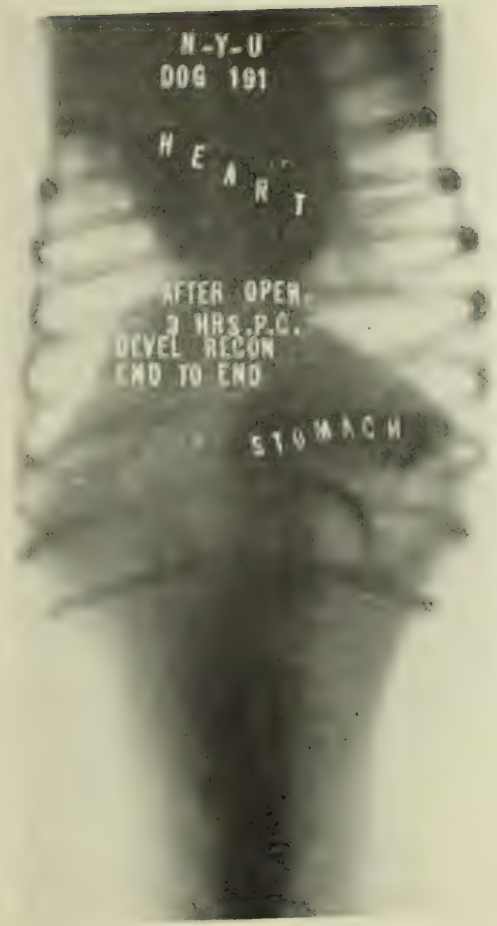

FIG. 4.—Dog 191. After developmental reconstruction of the colon: end-to-end anastomosis.

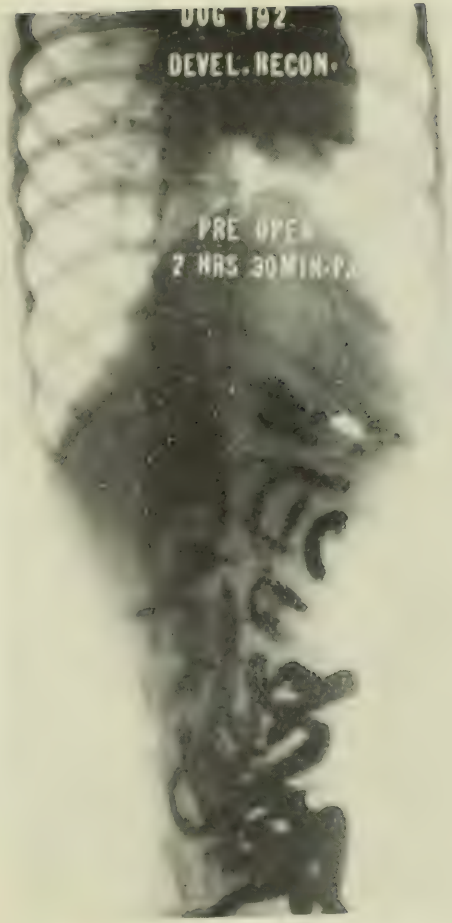

FIG. 5.—Dog 192. Before operation.

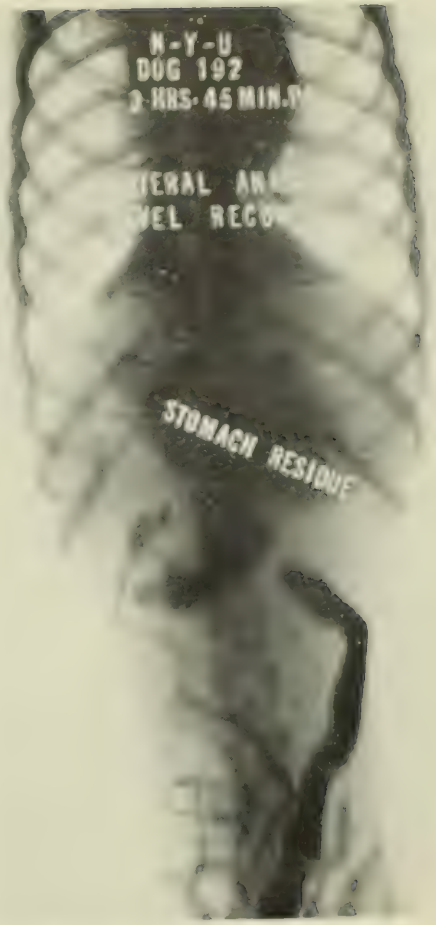

FIG. 6.—Dog 192. After operation for developmental reconstruction by lateral anastomosis.

reaching variations in the syndrome of human symptoms, varying in all grades from the neuromental to the arthritic, and which in properly chosen cases are cured or improved by right-sided resection, show the problem to be one of the most fundamental in all medicine. Obviously, it can be solved only by the combined efforts of both clinical and biological workers; the bioclinician having naturally the greatest opportunity for success.

EXPERIMENTAL STUDIES

These were made on dogs and were, of necessity, limited in scope, owing to the embarrassing fact that the ascending colon is normally lacking in the dog, and that like the ant-eater its duodenum and colonic bend are closely approximated. Thus the colon is exceedingly short and affords but limited chance for operative procedure. We have been, therefore, confined to a technical consideration of the effect of the modified developmental reconstruction which is possible in the dog upon the motility of the stomach as shown by X-ray and upon the relative merits of the lateral, the end-to-side, and end-to-end forms of anastomosis, as observed by the same agent. The accompanying table is self explanatory and supports in general what has been the usual holding in human surgery: that whereas the end-to-end technic gave the most ideal result, its high mortality made necessary a choice of either the lateral or end-to-side implantation.

DEVELOPMENTAL RECONSTRUCTION

Before operation			After operation			
	Elapse of time between meal and X-ray	Remarks—stomach emptying	Elapse of time	Remarks		Number of days post-operative
				Stomach emptying	Anastomosis emptying	
A						
End-to-end anastomosis, 3 cases:						
1. Dog 170....	2 hrs. 50 min.	Slight residue	3 hrs. 20 min.	Normal	No delay	7
2. Dog 174....	3 hrs. 40 min.	Slight residue	3 hrs. 25 min.	Delay	No delay	13
3. Dog 191....	2 hrs. 50 min.	Slight residue	3 hrs. 20 min.	Delay	No delay	14
B						
Side-to-side anastomosis, 3 cases:						
1. Dog 175....	3 hrs. 40 min.	Empty	3 hrs. 20 min.	Marked delay	Slight delay	10
2. Dog 192....	2 hrs. 50 min.	Slight residue	3 hrs. 40 min.	Marked delay	No delay	12
3. Dog 203....	3 hrs. 0 min.	Empty	3 hrs. 0 min.	Marked delay	No delay	12
C						
End-to-side anastomosis, 3 cases:						
1. Dog 186....	3 hrs. 5 min.	Residue	3 hrs. 15 min.	Moderate delay	No delay	13
2. Dog 198....	3 hrs. 10 min.	Residue	3 hrs. 10 min.	Slight delay	Delay	10
3. Dog 206....	3 hrs. 5 min.	Residue	3 hrs. 5 min.	No delay	No delay	6

No surgical research on animals can possibly be made without the conclusion that the persistence in man of the right colonic segment which has come to us apparently through the dominance of its experimental lengthening by the herbivora is ill adapted to our needs. Just what relation the upright position may have to the frequency of localized right-sided constipation, we are not prepared to say, because so little is known of the relations between gravity and intra-abdominal pressure. Constipation unquestionably is merely a part of the protective bodily mechanism. Having learned largely through Barber's researches[*] that gravity has little or nothing

[*] Barber, W. H.: Segmental Resection for Gastric Ulcer. ANNALS OF SURGERY, November, 1916.

to do with the emptying of the stomach after gastro-enterostomy, stoma position and neuromuscular gastric condition being the true determining factors, we are very loath to place much credence in the popular but ill supported theory that the human cæcum often does not empty because of gravity. We are, of course, ready to concede that this factor has its place in the causative syndrome, but realizing the markedly close analogy both as to physiology and as to morphology which exists between the stomach and the cæcum, and to which we have repeatedly referred in previous articles,[7] we feel quite certain that the gravity hypothesis is at best inadequate. Our hesitancy is further increased by the findings of our colleague, McFarland, whose pathological studies[8] of the cæcocolons removed by us show the tissue to present certain atypical characteristics, notable among these being the frequent presence of pigment. This we regard as a highly important contribution. This affords additional basis for the assumption that an inherent biological instability of the cæcocolon as developed in man is more responsible for the symptoms which unquestionably arise from it than the effect upon its emptying by gravity. There is undeniable decadence in function in all organs developing in the higher types in late fetal or early extra-uterine life. We must all remember that colonically speaking we are dogs at birth, the colon reaching only to the liver—thus the left colon, excepting only the pelvic portion, is of extreme age, of constant and important function, of fixed morphology as compared with the right which has not these important attributes. May it not be more logical to consider the relative importance of the right and left sides from the broad standpoint of phylogeny rather than from the narrow viewpoint of descriptive anatomy, and to base our therapeusis upon known biological laws rather than upon unproved and very questionable clinical hypotheses? This must be even more acceptable if the biological laws prove to be supported by our clinical therapeusis in individual human beings. Thus the cæcocolon may be considered the decadent wisdom tooth of the alimentary canal and be treated as such.

CLINICAL REPORT

In twenty-nine human cases of developmental reconstruction of the colon five have died, a mortality rate of 17 per cent. An analysis of this mortality is proper at this point because its degree would be deterrent and properly so in the employment by others of this operation. Four deaths occurred in the first eight cases. One death in the last twenty. An analysis shows two important facts. First, that we did not understand how to choose the cases. Second, that our technic has improved. The cause and time of death in the five cases is as follows: In two, both of them epileptic, shock in less than twenty-four hours after operation. In one, hemorrhage six hours after operation. In one, septicæmia, four weeks after operation. Autopsy showed an old perinephritic abscess, unrecognized at time of operation, as probable cause of death. One in a debilitated derelict, five days after operation, peritonitis. We have eliminated much of the post-operative shock by careful avoidance of all traumatism to the nerve centres near the duodenum. The post-operative hemorrhage death was due to the nurse's failure to report patient's condition until too late. The perinephritic abscess case in which death occurred four weeks after operation and in which all bowel functions

[7] Lynch-Draper: The Protective or Esoteric Symptoms of the Alimentary Canal. Virginia Semi-Monthly, March 24, 1916.

[8] McFarland, W. L.: Pigmentation of the Hind Gut. Journal A. M. A., December 8, 1917.

had been completely restored to normal, should not be charged against the series except in an indirect manner. Reclassifying the cause of death, therefore, we find that peritonitis, due directly to leakage from the anastomosis, caused one death, or 3.4 per cent. Shock in two epileptics, or 6.8 per cent.; septicæmia from long standing infection, one death, or 3.4 per cent.; accidental hemorrhage, one death, or 3.4 per cent. This analysis is in no way an attempt to minimize the danger and gravity of this operation, which we feel sure should not be undertaken except after the most exhaustive studies, until competent and long-continued medical care has proved unavailing, and then only by an experienced operator.

Effects of developmental reconstruction upon the patient's symptoms. In order to study these it is necessary to make an attempt at symptom grouping. For our purposes a classification of the patients into two general groups has served the purpose. The first, and by far the larger group, may be termed the "neuromental"; the second, much smaller, the "arthritic." This is an arbitrary setting which perhaps should be discarded and can no doubt be improved upon.

Something should be said regarding the methods employed to group the cases and to reach a decision as to operation. We consider it imperative that each patient should be studied by X-ray, and that the operation is indicated in exceedingly few cases that do not show cæcocolonic delay of 100 hours or more. The symptoms certainly are not due to constipation which we regard definitely as a protective symptom, but rather to the diseased state of the cæcocolon which permits passage of toxins arising either from bacteria or from the gut wall itself. This latter occurs in duodenal obstruction—why not in colonic? Satterlee's studies [9] of the chemical blood picture in colonic toxæmics (human) are of the utmost value and interest, tending, as

RESULTS OF EXAMINATION OF CASES OF CHRONIC INTESTINAL TOXÆMIA IN WHICH BLOOD WAS EXAMINED CHEMICALLY

Non-protein nitrogen	Over normal (45 mg. per 100 c.c.)	14 cases
	Under normal (30 mg. per 100 c.c.)	6 cases
Urea nitrogen	Over normal (25 mg.)	4 cases
	Under normal (15 mg.)	6 cases
	Normal	10 cases
Uric acid nitrogen	Over normal (3.5 mg.)	4 cases (highest 10.49 mg.)
	Under normal (1.0 mg.)	8 cases
	Normal but with subsequent rise	1 case
	Under normal with subsequent rise	1 case (sudden gout)
Creatinine	Over normal (0.5 mg.)	12 cases
	Under normal (0.1 mg.), sudden rise	1 case
	Normal (0.1–0.5 mg.)	7 cases
Blood sugar	Over normal (120 mg.)	6 cases
	Under normal (50 mg.)	0 cases
	Normal (50–120 mg.)	14 cases

[9] Personal communication.

the accompanying tables show, to indicate that a toxic element arises under conditions of partial or complete obstruction of the terminal gut similar in effect to that of duodenal obstruction, already published by me.

We also regard as imperative not only the removal of all possible areas of infection due to local foci, tonsils, teeth, crevices, etc., but even more particularly the repair of any and all local lesions such as hernia, hemorrhoids and the like, which may have important bearing through reflex inhibition of the right side of the colon. Needless to say, every case should be put through a complete laboratory study, including the Wassermann reaction. In one of our cases this, unfortunately, was not done, dependence being placed upon a 100-hour right-sided X-ray delay. Developmental reconstruction reduced the barium oro-anal time to thirty-six hours, due to the fact that the operation had enabled us to remove an extensive area of partial obstruction at the hepatic flexure—Lynch's " elbow deformity." The patient's symptoms of pain, referred to the rectum, however, persisted until we all, as he said, thought it was " in his head." An *"ex post facto"* Wassermann, however, was three plus.

Our earlier cases now date back nearly three years. The greater number are over one year and a half, the most recent is three months. It is, therefore, probably justifiable to present some utilitarian deductions based upon subjective and objective data. Careful and conservative study of the twenty-four living members of this interesting series shows at the very least a 75 per cent. improvement in efficiency and subjective symptoms. Incidentally, the more we study these cases the greater respect we have for the subjective testimony. The extraordinary accounts by these highly neurotic and often unbalanced patients have in the past been looked upon as worthless, but we have come to regard them with great respect, having often found at operation objective corroboration. Truly, as William Mayo has well said, in rejecting such testimony as a worthless fable, we ourselves are indeed the fool rather than the patient.

Technic.—We have resected the terminal 10 cm. of the ileum and the cæcocolon in block to the neighborhood of the right colic artery. This corresponds to a point upon the tranverse colon near to the right margin of the omentum. Since in practically all of our cases there has been a common mesentery of the cæcum and ileum so that the entire mass, particularly after careful separation of the mesenteric leaves, could easily be lifted above the belly wall so that both the resection and the anastomosis was done extra-abdominally, we have been able to avoid shock by keeping away from the duodenal centres. Keith's centre at the terminal ileum, while doubtless in close and important neuromuscular relationship with the duodenal centres, as proved by the interesting and conclusive experimental researches of Barber, may apparently be removed without adding surgical shock. This does not mean, however, that we consider ourselves at all informed as to the final post-operative result of its loss to the economy.

CASE HISTORIES: NEUROMENTAL GROUP

Mrs. R. B. E., aged twenty-eight. This intelligent woman is from the professional ranks and has had the best medical care. She was operated on two and a half years ago. Two healthy children, eight and ten years old. Chief complaint: Chronic constipation associated with extreme mental depression—suicidal; in the State Insane Asylum, Waverly, Mass., six years ago for six months. Husband was told by the alienists that she never could be cured; a hopeless mental case. Now reports herself 80 to 90 per cent. improved and able to care for her household and social duties; bowels regular; no cathartics. When presented recently before the Medical Progress Club of New York she replied to an inquiry as to what her chief trouble had been before the operation, "trying for fifteen years to keep from losing my mind."

Miss A. J. L'E. This woman is a descendant of an old Belgian family and knows her mind. Before operation she had been in the hands of a trained nurse under the most competent medical supervision that money could obtain. She had travelled with the nurse from the Gulf of Mexico to Labrador in the vain search for health. She was regarded by her family and attendants as deranged. Without provocation she flew into the most violent fits of uncontrollable rage. It was impossible for her to associate with anyone. She complained of the most frightful headaches, hemicranial in type. Her bowels were irregular, constipation alternating with diarrhœa. Two years and eight months ago developmental reconstruction was done. Her cæcocolon was grossly and microscopically atypical, being filled with pigment, and the mucosa being nearly destroyed. That this woman's symptoms were directly attributable to the absorption of unknown products from this degenerated and sac-like bowel segment is undeniable, for not only has she returned to her arduous work of teaching, but her headaches are 95 per cent. diminished, her bowels are regular, and she is able to associate with her fellow beings.

Mrs. M. E. R. This woman, forty-four years of age, was for years a chronic sufferer with hemicranial headache; in bed for five days with each attack. In 1909 she had 67 headaches; in 1910, 59; in 1911, 65; in 1912, only 35 (this she attributed to rigid abstinence from meat); in 1913, 49; in 1914, 50; in 1915, 65 (the diet had been rigidly maintained, but the headaches had now reached their former maximum). Developmental reconstruction six months ago. Constipation cured; one headache only, which patient attributed to her over-indulgence socially. Of particular interest from a biochemical standpoint is the fact that she has added both meat and eggs to her diet. For the past six years she had not been able to eat an egg without being certain of having a headache.

ARTHRITIC GROUP

We have had but one case presenting uncomplicated multiple arthritis. We offer no explanation for this curious evidence of selective action of the toxins. It has happened that this case was evidently well chosen, for she has been rendered 80 per cent. efficient by develop-

mental reconstruction of the colon. While the arthritis was marked in the lower extremities, the patient could still walk by a sort of creeping gait. She had not been able to feed herself except occasionally with a spoon for over two years. She had not been able to turn over in bed for two years; she had not been able to write for three years. After every possible source of infection had been sought for elsewhere, it was decided that the toxins were being distributed from her colon where she presented 100-hour right-sided delay. Seventeen months ago developmental reconstruction was done. In thirty-six hours the patient affirmed that every vestige of pain had left her body and that it was the first time in three years that she had not suffered pain day and night. More remarkable to us was the change about the small joints. How the scarlet color could be blanched as it was in thirty-six hours still remains a mystery. We are aware that Bottomley and others have not had as gratifying results as we are able to report in this case. Whatever the future of this individual may be as to relapse and recurrence, the study of her post-operative condition is of the utmost value in proving that in her case at least the toxins did come from a diseased cæcocolon.

INDICATIONS FOR DEVELOPMENTAL RECONSTRUCTION

1. Segmental infection of the cæcocolon. Like any other infected hollow organ it is a constant source of danger.

2. In Lynch's elbow deformity of the mid-ascending colon when the peritoneum cannot be repaired after reduction.

3. In exaggerated non-fusion of mesentery, allowing such freedom of motion as occasionally to result in volvulus. This happened in one of our series.

CONCLUSIONS

1. Developmental reconstruction of the colon is an operation which finds justification in heredity, in well-known laws of biology and in clinical study.

2. It is a procedure fraught with danger and one which never should be undertaken until, not alone exhaustive studies have been made, but until modern and well-directed medical therapeusis has failed.

3. Ileosigmoidostomy is unphysiologic and has therefore failed.

4. The subjective symptoms for which the operation is indicated are usually neuromental; the objective symptom is cæcocolonic degeneration. The degree of improvement in our series is amply sufficient to justify the operation in selected cases.

5. Developmental reconstruction has superseded in our clinic all the earlier forms of operative procedure such as ileocolostomy, cæcosigmoidostomy, etc., because we have found it to be no more dangerous operatively and to give better results because it removes the biologically decadent and diseased organ and restores the individual to the carnivorous type of colon undoubtedly best suited to man.

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CANCER OF RECTUM*

By Jerome M. Lynch, M.D.
of New York
MEDICAL RESERVE CORPS U. S. A.

Cancer of the rectum and colon has increased one hundred per cent. in the past fifteen years according to the report of Vital Statistics of the Registration Area of the United States. Bloodgood has well said that in the life history of every malignant growth there has been a moment when it was surgically curable and the lesions under consideration offer no exception to this admirable axiom. To recognize and to seize upon this precious moment is no less than to control the life destinies of the affected individual.

Results of Surgical Treatment.—Of 491 cases studied we have operated upon 335. The hospital mortality was 16 per cent. Forty-one have lived one year; 45 two years; 33 three years; 22 four years; 26 five years and 17 six years.

Patients not replying to circular letter have been classified as dead when last heard from. As in all clinics situated in cosmopolitan centres where the population is in constant flux, it is impossible to follow a large number of the patients. Thus the statistics as above created are necessarily less favorable than if every case had been followed to date.

Whatever disability exists as results of operation does not interfere with livelihood gaining. One of our patients who was bankrupt when his rectum and sphincter were removed, and who leaks at times, now makes four trips to Europe and has earned over a million dollars since operation. We cannot overemphasize the plain fact that post-operative conditions, no matter how unfavorable as to function, do not interfere with the usefulness or economic independence of the patient.

Incontinence is a relative term. Its importance has been grossly exaggerated. As no horse is sound, so no human body is without defect, and even great defects are compensated for by the natural endowment of the individual to meet such obligations. It is simply a question of getting used to the discomforts of a colostomy or a leaking anus—a psychological phenomenon well worthy of consideration. Think of the innumerable women torn in childbirth who have been incontinent for a quarter of a century, yet who efficiently and without affront to their families perform their daily work. Because of this psychological element we strongly prefer to have a relatively incontinent normal anus rather than upon the abdomen. This, briefly, is the result of surgical therapeusis in our series.

What stronger argument could there be for discussing the diagnosis and the indications? These statistics show that rectal cancer operated upon even after great delay and by poor methods is not hopeless. If with these

* Read before the American Gastro-Enterological Assn., May, 1917.

limitations we get results, how important, therefore, is the early diagnosis and how promising the outlook for the future.

What have been the methods of study in this series of 491 cases? Of first importance is a flat contradiction of some still prevailing convictions, to wit: That the operation is hopeless; that the cancer patient is cachectic or has lost weight; that age is of importance; that pain is a prominent symptom and that a tumor can always be felt. The very occurrence of these symptoms spells inoperability.

What are the important symptoms from the modern standpoint in order of diagnostic and therapeutic importance?

First, constipation: This we believe to be the very first and earliest of all symptoms. It is undoubtedly protective in type, being perhaps the result of biologic reaction to the influence of the new-growth. There are, however, several hypotheses as to its origin depending upon the path of inhibitory

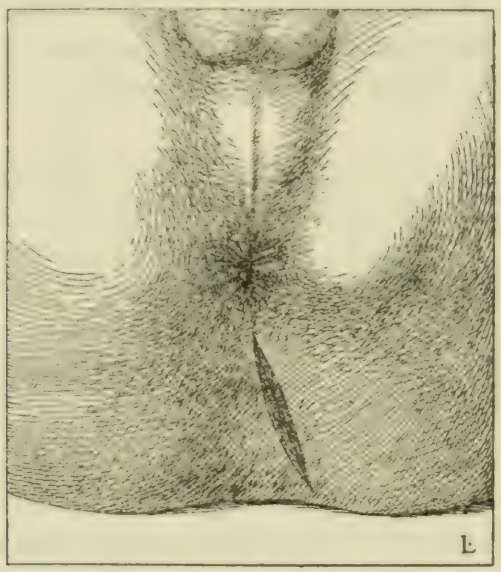

FIG. 1.—Shows where the first incision should be made when performing a perineal operation.

transmission rather than upon its origin or occurrence. Of the latter and of its protective nature there can be no doubt. Certainly it is not due to mechanical obstruction of the growth.

Second, stomach symptoms: We have repeatedly referred to these as esoteric as contrasted to hemorrhage and the like which are exoteric. Chronic indigestion, so frequent a sign of peripheral pathology, is just as significant of rectal cancer as of a chronic appendix.

Third, blood or bloody stools: This is usually the first exoteric sign. It can occur without ulceration, in which case it may be due to a blocking of the return circulation in the valveless veins leading to the liver. In any event hemorrhage so commonly associated with cancer (10 per cent. of our cases of 491 had been operated upon previously to our seeing them for hemorrhoids) is a frequent source of the blood. In a large proportion of the cases, however, it is due to ulceration.

Fourth, frequent and imperative desire to move the bowels followed by explosive discharges of gas, blood and mucus: This symptom is usually spoken of as the diarrhœa of cancer. It is not in reality a diarrhœa in that fæces are rarely passed.

These are the classical symptoms which every gastro-enterologist should know. Other symptoms occasionally noted are an indefinite pelvic discomfort and pain or tenderness over the cæcum which has been mistaken for right-sided pathology.

Diagnosis.—A patient presenting any one of the above symptoms should have a rectal and proctoscopic examination as a matter of routine. In our series of 491 cases, 56 per cent. of the tumors were within 7.5 cm. of the anus; 69 per cent. were within 10 cm. of the anus, and 31 per cent. were oral to this. It is quite evident, therefore, that more than a half were within

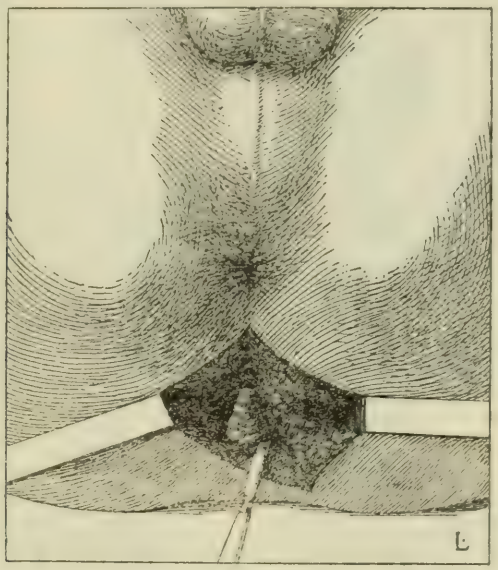

Fig. 2.—Illustrates the method of removing the coccyx.

reach of the finger, that two-thirds could have been diagnosed under anæsthesia by the finger, and that all except the sporadic cases in the colon could have been diagnosed by the proctoscope.

Duration of symptoms in this series was eight months. During this period many of the cardinal diagnostic symptoms already referred to had been present, so that at any time a diagnosis could have been made had the patient been examined.

Age.—In our series of 491 cases 4 per cent. were under thirty years of age; 7 per cent., thirty-five. According to the United States Bureau of Vital Statistics 5 per cent. of cases of rectal and colonic cancer were in children under nine years of age, 2.75 per cent. under nineteen years, proving that cancer is not confined to any age and that, while it occurs more frequently in middle life, still, for all, we must recognize the danger of placing too much importance on age.

A word must be said regarding the pernicious habit of biopsy for diagnosis. At the Symposium on Inoperable Cancer of the New York Academy of Medicine, Dr. Robert Abbe remarked that in the treatment of carcinoma by radium, the biopsy wound itself was one of the last to heal and was very stubborn.

TREATMENT.—*Operability.*—In our series of 491 cases extending over a period of nineteen years, 153 were considered inoperable. Of great importance is the history of the advance of our technic and a more liberal understanding of the possibilities. From a study of unexpected results in many so-called inoperable cases we are convinced that even in the late cases, except when the peritoneum is involved, there is always a fighting

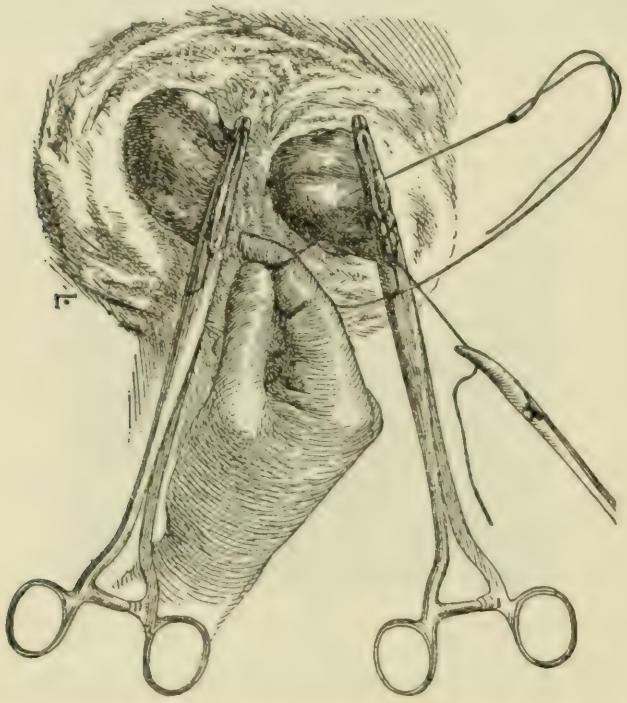

FIG. 3.—Illustrates the technic to be followed for dividing the bowel, when it is intended to leave the patient with a permanent colostomy and subsequently to remove the aboral portion of the sigmoid and the rectum.

chance. Of the 153 cases considered inoperable, none have been so classified because of the extent of involvement in the rectum itself.

Our operability for the total number is 60 per cent. This high percentage is due to the fact that Doctor Tuttle kept no record of inoperable cases. By operability is understood radical extirpation of the growth. In the past five years our operability has risen to 74 per cent. Let it be clearly understood that this refers to growths strictly localized in the rectum. As to the indications for radical treatment; when adjacent organs are involved our statistics show that we have often removed a part of the vagina, a part or whole of the prostate, seminal vesicles, urethra and uterus, several coils of intestine and part of the bladder. In many instances it is necessary to perform an exploratory laparotomy to determine whether the growth is operable.

Choice of Operation.—Operable cases: (1) Combined; (2) perineal; (3) abdominal.

We have performed the combined operation 111 times; in 36 of these cases it was performed in two stages. It is our operation of choice.

The perineal has been performed 102 times; the abdominal 20 times. Formerly we used the following operations now in disuse: Kraske, 20; modified bone flap, 32, and intrarectal, 18. When possible, for the psychical reasons already described, we always place the anus at the normal site. We prefer to perform the operation in one stage if it is possible, but, if necessary, we divide it into two stages.

The perineal operation is our operation of choice in very fat or in extremely debilitated people (Fig. 1). In all cases, as a matter of routine, we always remove the coccyx (Fig. 2). Preliminary colostomy is always done

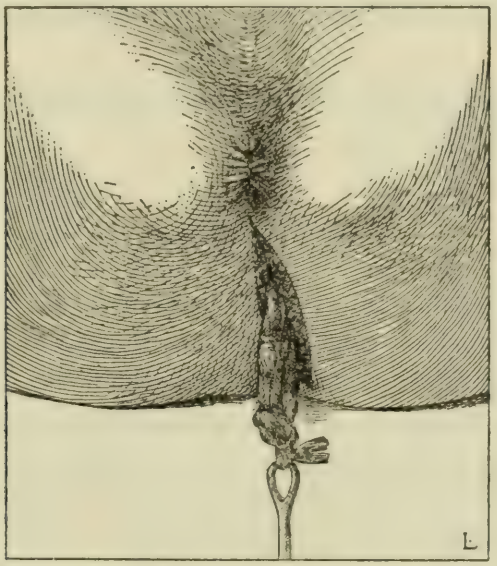

FIG. 4.—Illustrates the method of invaginating the proximal end of the aboral sigmoid and rectum.

when the growth is within 2 cm. of the anus, in order to prepare for the extensive removal *en bloc* necessitated by lymphatic involvement.

We have for some time abandoned rectal resection for the reason that in all of these cases the operation was followed by stricture. This is due to the presence of a terminal blood supply in the rectum rather than, as commonly supposed, to the absence of peritoneum. Exceptional work on dogs has been done by Barber which has confirmed us in this belief. It is the ischæmic rather than the peritoneal denudation that produces the stricture. It is axiomatic that the amount of scar tissue is in reverse ratio to the blood supply. This important contribution will form the basis of a subsequent paper.

Palliative Operative Treatment.—What can be done in this type of case is still of great importance. Until earlier diagnoses are made many cases will continue to fall in this class. If this paper served no other purpose than to convince the profession of the necessity of early colostomy in

inoperable carcinoma of the rectum it will have done some good. The fixed attitude toward colostomy is that it should be postponed until obstruction supervenes. This is certainly not in accord with the facts as we find them in 36 cases for cancer alone and in over one hundred for other conditions. It can be done, if necessary, under local anæsthetic.

What are the advantages of early colostomy in inoperable cancer as opposed to the supposed disadvantages? It reduces the inflammation, often converting an inoperable into an operable case. It obviates intestinal obstruction and its accompanying symptoms of pain, constant secretion and defecation, permits rest and sleep and insures recuperation. The patient renews his normal routine as to habits and diet. It stops hemorrhage. In short, it places the parts at surgical rest. If early it is without notable mortality; if late this rises to 40 or even 50 per cent.

Local Cauterization.—This is frequently of great value; it stops pain and limits secretion and odor. If frequently repeated it may keep a patient alive for many months.

Treatment by radio-active substances, fulguration and by biochemical derivatives is not here considered.

CONCLUSIONS

1. We would urge that digital and proctoscopic examinations be made routine in all patients presenting gastric or intestinal symptoms. If this is adapted a great many cases will be diagnosed early and saved.

2. That all cancer cases should be referred to a surgeon, as he is best fitted to pass judgment as to whether they are suitable for operation or not.

3. If inoperable, colostomy should be performed as soon as possible, thereby saving much suffering and discomfort.

4. That no patient should be denied a radical operation until it is proved beyond doubt that it is not justifiable.

5. That our technic is now more perfect and consequently we are saving many cases which previously died from shock and peritonitis.

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CHOLEDOCHO-ENTEROSTOMY AND POSTOPERATIVE DILATION OF THE BILE-DUCTS

AN EXPERIMENTAL STUDY

BY WILLIAM HOWARD BARBER, M.D.
OF NEW YORK, N. Y.
ASSISTANT SURGEON, BELLEVUE HOSPITAL

(From the Department of Surgery, New York University and Bellevue Hospital Medical College)

SUTURE operations are quite often undertaken upon the common bile-duct in human surgery because the dilation of pathologic ducts makes them practicable. There are conceivable emergencies in which one may be forced to unite a small-sized common or hepatic duct to a loop of intestine or to the stomach and in which an oblique anchorage method may be helpful.

According to Baudouin, the first apparent attempt to perform choledochoenterostomy belongs to Riedel. Riedel, in 1888, endeavored to close a choledochostomy by suturing the bile-duct to the intestine. In 1890 Kocher failed to overcome a bilioduodenal fistula by a plastic operation upon the end of the bile-duct. In the following year, the first successful choledocho-enterostomy was carried out by Sprengel in a woman upon whom he had first done a cholecystectomy.[1] Guerry [2] has recently reported four symptomatic cures out of seven direct anastomoses. Mayo's [3] studies and successful case, published in 1905, emphasized the possibilities of end-to-end common duct and of end-to-side bilioduodenal union. Foreign substances have been introduced by Horsley,[4] Lewis,[5] Davis,[5] and others in efforts to abridge the gaps between the intact ends of partially destroyed bile-ducts. To this end, veins, fascia, and the appendix have been proposed but have not met with promising success. Sullivan's [6] suggestion of the use of the rubber tube has probably met with the most favor in this respect. At the present time, the indications appear to be for direct anastomosis when possible, and for indirect union by means of a rubber tube, as proposed by Sullivan and developed by Mayo, when necessary.

Any procedure to reunite a partially destroyed bile passage is made difficult by the inaccessibility of the operative field and by the large numbers of adhesions. A destruction of the common duct where the gall-bladder is absent or, for other reasons, unavailable for cholecyst-enterostomy impels the prosecution of some form of choledocho-enterostomy. In isolated instances, hepatico-enterostomy has been tried in spite of the dangers of liver abscess and of the difficulties of suturing gut

to liver. On one occasion, Stewart [7] opened the duodenum and sutured it about the portal fissure in the hope that bile would eventually find its way into the intestine. Tumor, calculus, or stricture may seriously interfere with the entrance of bile into the intestine. A duct may be divided or resected intentionally or accidentally at operation or it may be severed in a gunshot wound * by a bullet passing through the abdomen. The frequency of these causes of duct injury, in which choledocho-enterostomy may have to be resorted to, is well shown in Mayo's statistics of 159 common duct operations out of 1100 operations upon the liver and bile passages with complete loss of continuity of the common duct in 7. Of these, 5 were severed purposely during resection for carcinoma, 1 was unintentional, and 1 followed extensive operation for gall-stone disease.[8]

The following experiments are based in part upon experience in ureterocolostomy and in part upon the reports of others on bilioenteric anastomosis. As may be seen from the illustrations, the ligated bile-duct is drawn through the submucosa of a mobilized loop of small intestine or stomach, into the lumen of the same, and left fixed by the ligature in the exit needle-puncture opening. The end of the duct within the lumen of the bowel and below the ligature may be incised to provide for the immediate escape of bile, or, apparently, this step may be omitted with impunity, for, under the conditions of the experiment, bile may not enter the distal part of the transposed duct within two days, and the duct ends are found free in three days. Ninety per cent. of the animals represented had transplantations without this provision for spontaneous bile drainage. It is important not to disturb the terminal fascial connections of the duct any more than is absolutely essential. As in the ureteroenteric transplantations, the operative technic is simple and free from local infections but subject to the dangers of bile-duct dilation and ascending biliary infection.

Autopsies performed at various times during the postoperative life of these animals disclose many interesting findings. Ascending infection of the liver unfortunately has not been excluded and may have caused the death of certain of the apparently successful animals. In those instances in which the bladders were dilated, the livers, too, were deeply congested. In all the experiments, the ducts are found dilated, no matter at what time examined. At the end of the second day, the intramural segment is remarkably firm, due, apparently, to the fascial connections outside the bowel, to the exudative and fibrinous agglutination of the omenta, liver, and anastomotic loop, and to the enlargement of the intraintestinal end. The ligated end early retracts within the lumen, becomes swollen and congested, is free from the ligature in about three days, and ultimately disappears altogether. There is no evidence of persistent irritation about the new opening, which is beyond detection excepting at such times as

* One gunshot wound of the common duct came under the department of surgery and was operated upon by Cramp during the past year.

FIG. 1.—This represents the first stage in bilioenteric anastomosis. The common bile-duct has been divided distal to a ligature with the ends left long, as indicated. It is apparently not necessary to ligate the duodenal end of the divided duct, for in no instance has leakage been found to have occurred from the united stump. A loop of small gut is brought up into the wound and in the vicinity of the free end of the duct.

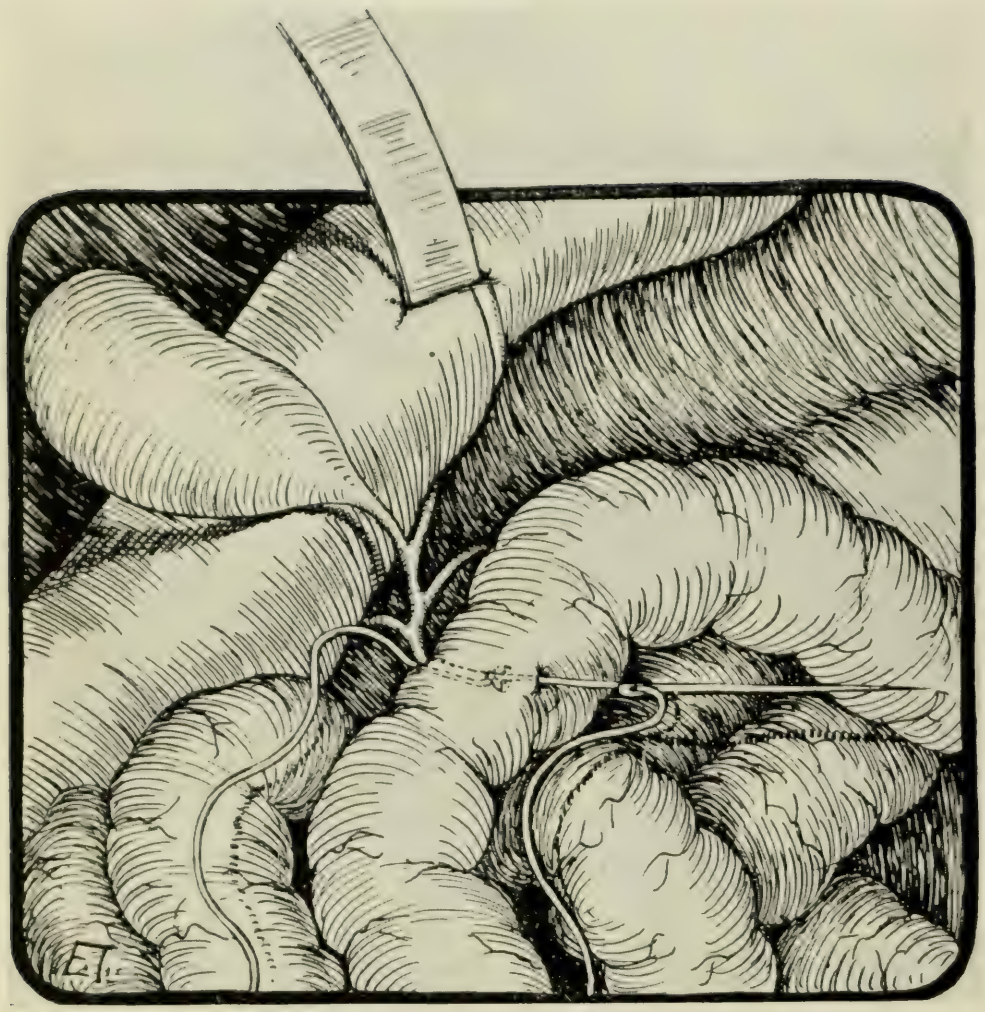

FIG. 2.—A straight, fairly large-sized needle is attached to an end of the ligature and is run through the intestinal wall for a distance of 1.5 cm. The needle and duct are made to enter the lumen of the bowel and, immediately, to emerge perpendicularly. The trailing end of the ligature is recovered and held.

FIG. 3.—This exposed and ligated end of the bile-duct is fixed in the exit from the bowel by a simple anchorage suture. The original ligature is utilized for this suture, as indicated.

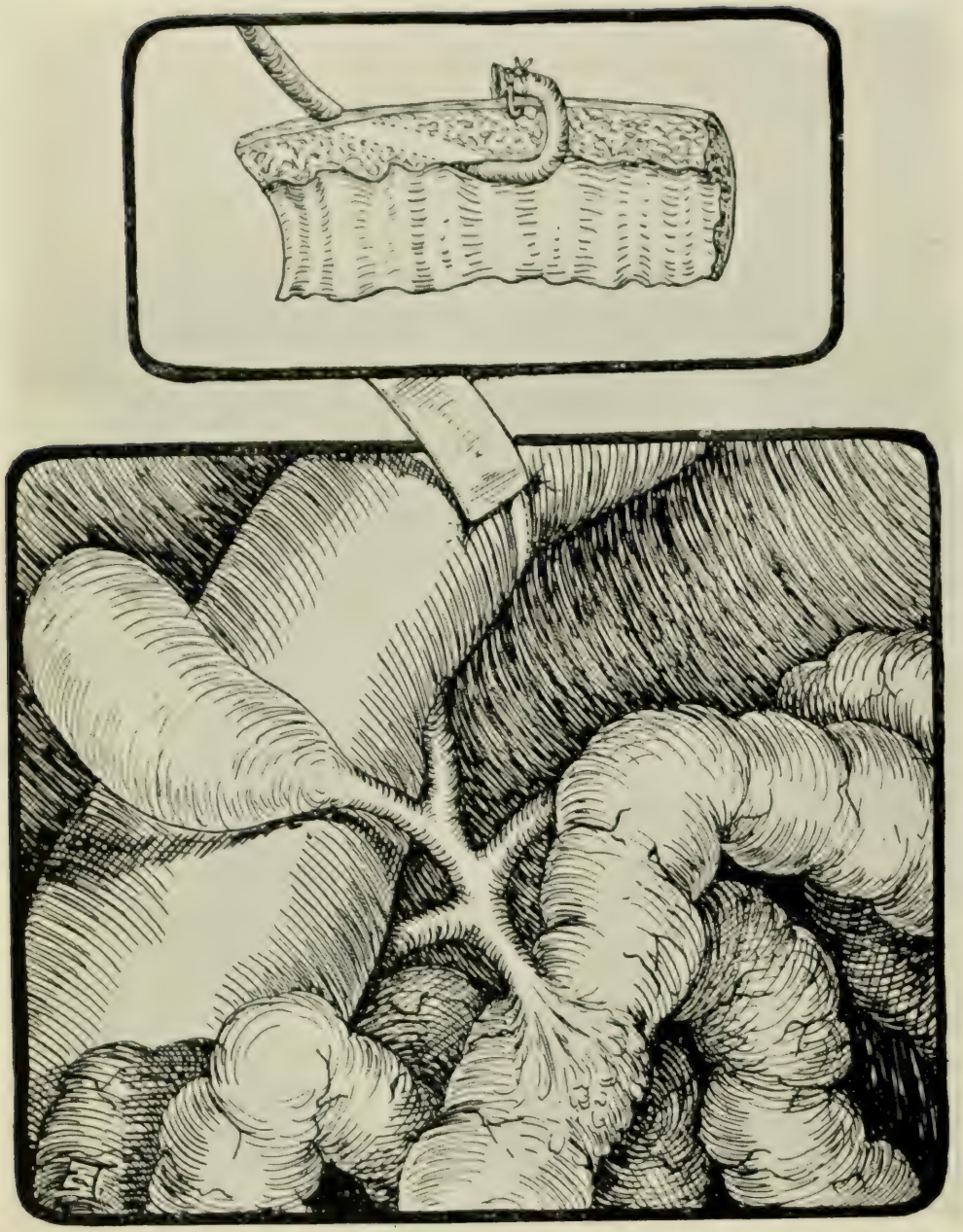

FIG. 4.—This represents an after-result and is taken at random from one of the "intact" animals. Note particularly the degree of gall-duct dilation. The insert above shows the relationship of bile-duct to intestinal wall and to lumen of bowel immediately after operation. Retraction probably always occurs, making leakage at exit impossible.

FIG. 5.—This is a photograph of a similar animal after euthanasia. Note loop of intestine opened up and duct stoma. This opening is free from evidence of irritation and can be discerned only by watching for the appearance of bile during pressure over bladder. Note relative sizes of duct and bladder.

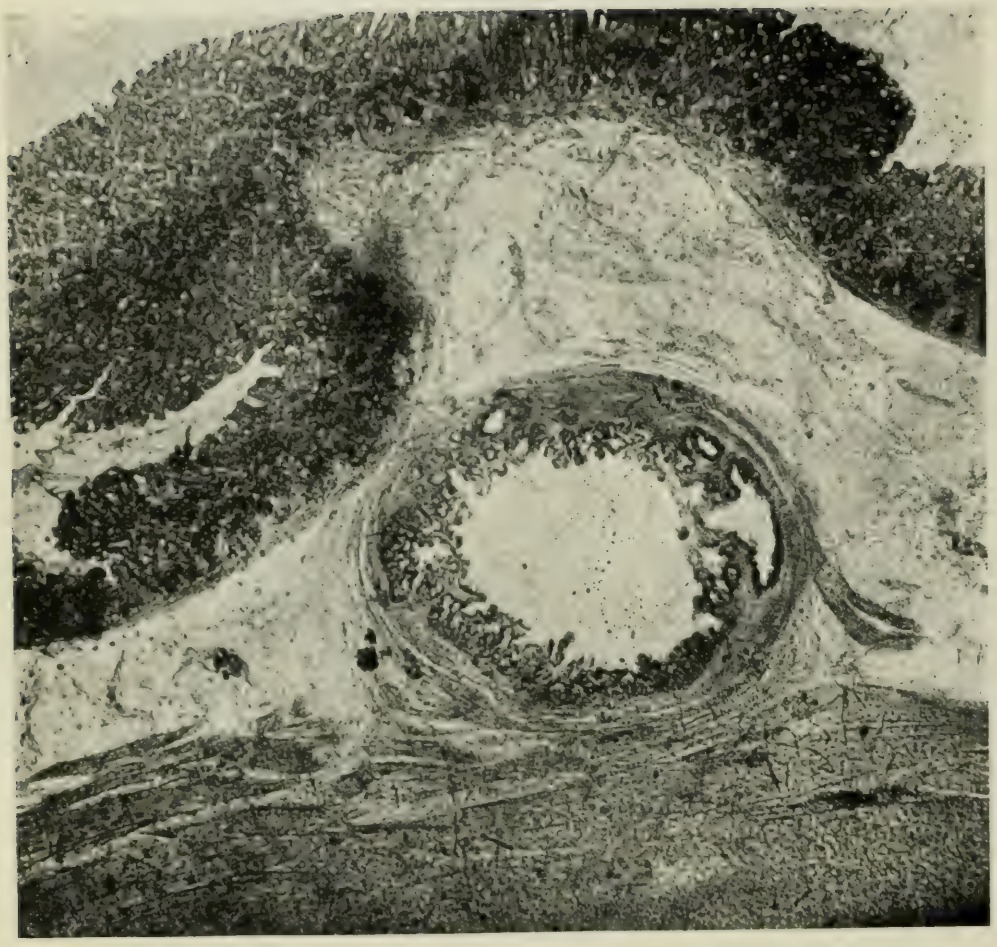

FIG. 6.—Microphotograph of a cross-section of an "intact" bilio-enteric anastomosis. Note duct lying in submucosa of intestinal wall. Note size of duct lumen and integrity of duct wall.

FIG. 7.—Microphotograph of a longitudinal section of a successful bilio-enteric anastomosis. Note relative sizes of intramural and extramural bile-duct, transition of lining epithelium, and integrity of duct wall.

FIG. 8.—Microphotograph of a longitudinal section of an unsuccessful bilio-enteric anastomosis. Note marked dilation of extramural duct as compared with the intramural segment, diminished size of the intestinal portion, and beginning disintegration of the bile-duct, presumably from increased pressure.

bile is seen to come from it. The needle punctures and ligature-suture are amply protected by exudative material and scar tissue. The mucosa of the intestine is continuous with the lining membrane of the bile-duct in most of the transplants and is interrupted in some, but not all, of the badly obstructed animals (Fig. 8). In the great majority of the dogs, the bile-duct, anastomosis, and the anastomotic intestinal loop are free from gross and microscopical evidence of disease aside from the biliary dilation which, to some extent, is common to all.

This dilation appears in the ureteral transplants [9] as it does in these animals after gall-duct transplantations and is evidently of nervous origin. In studying the relation of trauma to the neuromuscular function of the ureter, it was shown that the regular contractile wave in the dog's ureter recurred at nine-second intervals, but that when the nervous connections in the wall were impaired this peristaltic wave dropped off to twenty-five and sixty-nine second intervals, respectively, according to the degree of ureteral trauma. In many of these animals with known disturbed ureteral nerve connections, hydroureter and hydronephrosis developed. The relation of these dilations to possible nervous causes has recently been emphasized by Braasch.[10] In respect to the bile-duct, peristalsis, as far as I am aware, has not been observed and can not be studied in relation to trauma, but dilation certainly does follow division and transplantation. The bilioduodenal sphincter (sphincter of Oddi), like the ureterovesical "valve," stands as a barrier between open and closed systems against harmful pressure changes and ascending infection. These functions are well illustrated in Archibald's [11] excellent work on the biliary system. The direct nervous connections of this sphincter with the bile passages on the one hand and with the duodenum on the other are destroyed in division of the common duct. This interference with the neuromusculature of the duct and the loss of the "valve" probably unite to cause that apparently harmless biliary dilation occurring in all transplantations.

The present series comprise twenty animals, fourteen of which are successes barring the dilation above described and the possibilities of ultimate ascending infection of the liver, and six are partial or complete failures due to harmful compression of the intramural segments of the transposed bile-ducts. Four of these failures occur in the thick-walled stomach and two in the duodenum. In the relatively thin-walled jejunum the stomata are the most patent.

The following conclusions suggest themselves:

1. A severed bile-duct too small for sutures but long enough for direct choledocho-enterostomy may be reunited to the upper small intestine or the stomach by anchoring it obliquely within the wall of the intestine or the stomach.

2. Of twenty animals, eighteen, with temporarily obstructed ducts, developed patent functionating anastomoses in 72 per cent., and two

with provision for spontaneous drainage. Of these latter, one animal has had a perfectly functionating anastomosis for four months.

3. A certain degree of dilation due to the inevitable interruption of the nervous connections during reconstruction of the bile-duct is not incompatible with life. Harmful dilation is associated with retraction of the transposed end, obstructive intramural scar, and deficient epithelialization.

4. The above technic reduces to a minimum the adhesion-forming traumata, and the factors in it tending to prevent the retraction and obstruction of the bile-duct are: (1) Proper mobilization of the anastomotic intestinal loop, (2) the oblique course of the intramural segment, (3) possibly the dilation of the intraintestinal end, and (4) anchorage of the bile-duct with due allowance for retraction.

SERIES NO. 1. EXPERIMENTAL CHOLEDOCHOGASTROSTOMY

Serial No.	Exp. No.	Postop. Life in days	Anatomical result: Gross and microscopic		Physiologic
1	4	23	Retraction; obstruction	.....	No bile on pressure.
2	11	32	Retraction; obstruction	....	No bile on pressure.
3	18	17	Intact.....	Continuous layer of epithelium	Bile on pressure.
4	20	24	Partial retraction; obstruction	.....	Bile on plus pressure.
5	33a	10	Intramural stenosis	Obliterative inflammation	Bile on plus pressure.
6	28	44	Intact.....	Continuous layer of epithelium	Bile on pressure.
7	42	35	Intact.....	Continuous layer of epithelium	Bile on pressure.
8	69	59	Intact.....	.....	Bile on pressure.
9	33	99	Intact.....	.....	Bile on pressure.

The duration of life represented in Series 1, 2, and 3 does not give the number of days the animals could have lived; for in many instances the experiments were terminated by euthanasia.

SERIES NO. 2. EXPERIMENTAL CHOLEDOCHODUODENOSTOMY.

Serial No.	Exp. No.	Postop. Life in days	Anatomical result: Gross and microscopic		Physiologic
1	12	38	Intact.....	Continuous layer of epithelium	Bile on pressure.
2	1	49	Intact.....	.....	Bile on pressure.
3	43	25	Intact.....	Continuous layer of epithelium	Bile on pressure.
4	35	42	Intact.....	Continuous layer of epithelium	Bile flows spontaneously.
5	27	68	Intact.....	Continuous layer of epithelium	Bile on pressure.
6	32	60	Retraction; obstruction	.....	No bile on pressure.
7	41	41	Retraction; obstruction	.....	No bile on pressure.
8	94	120	Intact.....	Continuous layer of epithelium	Bile flows spontaneously.

SERIES NO. 3. EXPERIMENTAL CHOLEDOCHOJEJUNOSTOMY

Serial No.	Exp. No.	Postop. Life in days.	Anatomical result: Gross and microscopic		Physiologic
1	40	19	Intact.....	Continuous layer of epithelium	Bile flows spontaneously.
2	62	?	Intact.....	.....	Bile on pressure.
3	70	17	Intact.....	.....	Bile flows spontaneously.

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URETERO-ENTERIC ANASTOMOSIS

A FURTHER EXPERIMENTAL STUDY *

W. HOWARD BARBER, M.D.

NEW YORK

The problem of the disposition of the ureter that has been separated from the bladder by accident or reason has engaged the attention of many thoughtful and ingenious surgeons for the past sixty-five years. The feat has been attempted from different points of view. To prevent peritonitis, Lloyd and Simon[1] worked extraperitoneally. To preserve the immediate ureteral vesical relations, Pisani, Peterson,[2] Maydl and Moynihan transplanted both of the ureters and the adjacent portions of the bladder involving the area of the trigonum vesicae. To accomplish both at once, Bergenhem[3] removed the ureterovesical rosettes separately and extraperitoneally.

Again, to protect the transposed ends of the ureters from contamination by the fecal stream, Gersun,[4] Tizzoni, and Pozzi substituted for the bladder evaginated intestine and transplanted the severed ureters into it. Martin,[5] Kryinski,[6] Fowler,[7] Boari[8] and numerous others, without removing any portion of the bladder or without creating one artificially, anasto-

* Read before the Section on Genito-Urinary Diseases at the Sixty-Sixth Annual Session of the American Medical Association, San Francisco, June, 1915.

* From the Laboratory of Experimental Surgery, New York University and Bellevue Hospital Medical College.

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7. Fowler: Implantation of the Ureters into the Rectum in Exstrophy of the Bladder, with a Description of a New Method of Operation, Am. Jour. Med. Sc., 1898, cxv, 270.

8. Boari: Ann. d. mal. d. org. génito-urin., 1896, xiv, 1.

mosed the ureters to the lower bowel directly. They endeavored to elaborate a defensive barrier in the union of the extreme caudal ends of the ureters with the normal bowel. Tuffier, Coffey[9] and Beck[10] attempted the same result, but allowed the ureteral ends to protrude into the intestinal lumen. All these workers[11] have striven to produce, largely through anatomic study, a perfectly functionating entero-ureteral anastomosis.

Reviewing these different technics in entirety, they appear to have been suture methods (with the possible exception of Boari's, in which a button was used) and contrivances retaining the ureterovesical valve or its equivalent. Especially painstaking seem to have been the efforts spent to create resistance at the caudal end of the ureter equivalent to that presumably present in the normally intact ureter. Fowler[7] pertinently criticized the Maydl operation for "making no allowance for the changed pressure conditions of the rectum" and for involving "extensive dissection," and Kryinski's method in that the "pressure exerted was fallacious in accomplishing the result" desired, while at the same time Fowler buried his ureter for an arbitrary distance and consequently with an unknown resistance in the muscular fibers of the rectum. Coffey[9] called his enteric implantation of the ureter "physiologic," while simulating the anatomy of the ureterovesical termination. The latter method has been followed by C. Mayo[12] in four cases recently reported by him. It seems to me, however, that the physiology of the ureter has for the greater part been disregarded, for it is believed at the present day that the ureterovesical valve is negligible physiologically. This dissimilarity between the pressure conditions of the intestinal tube and the closed urinary bladder further emphasizes the impertinence of a vesical ureteral termination in the bowel.

A further objection to all the operations to date is appropriately described by Matas,[6] thus:

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9. Coffey, R. C.: Physiologic Implantation of the Severed Ureter or Common Bile Duct into the Intestine, The Journal A. M. A., Feb. 11, 1911, p. 397.

10. Beck, C.: Chicago Med. Recorder, November, 1899.

11. Ricketts, B. M.: Surgery of the Ureter: an Historical Review, 1905, p. 1585. Hartley, F.: The Operative Treatment of Exstrophy of the Bladder. See also Footnotes 2 and 6.

12. Mayo, C.: Exclusion of Bladder, an Operation of Necessity, Collected Papers of St. Mary's Hospital, 1913.

The operator who cuts off both ureters from the bladder and transplants them into the colon, must experience a certain and unavoidable anxiety—an anxiety that only further experience will overcome, that is born of the feeling that

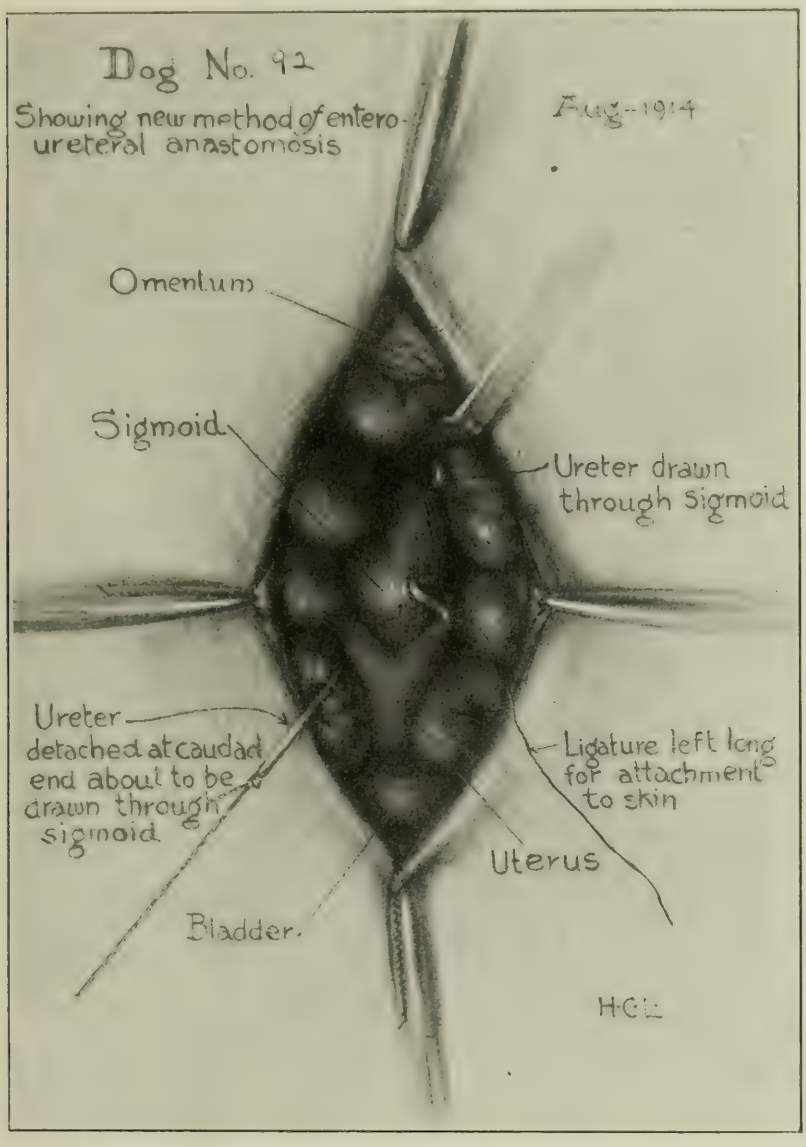

Fig. 1.—New method of entero-ureteral anastomosis.

he has burned his ship behind him and has staked all his patient's chances, all his hopes in the hazard of the game. It is the utter hopelessness of remedying the evil that must make any conscientious operator vacillate many times over before deciding to embark on so perilous an undertaking.

A number of salient physiologic facts were brought out by our laboratory studies during the past two years. It was determined by Draper and Braasch[13] at the Mayo Clinic in 1911 that the ureterovesical

Fig. 2.—Ventral view.

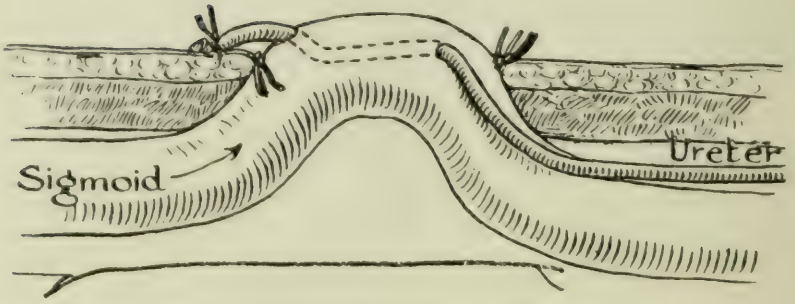

Fig. 3.—Lateral view, semidiagrammatic.

valves may be destroyed in the presence of purulent cystitis without probable kidney infection. It was evidently probable from the studies[14] presented at

13. Draper, J. W., and Braasch, W. F.: The Function of the Ureterovesical Valve, THE JOURNAL A. M. A., Jan. 4, 1913, p. 20.

14. Barber, W. H., and Draper, J. W.: Renal Infection: A Further Experimental Study of Its Relation to Impaired Ureteric Function, THE JOURNAL A. M. A., Jan. 16, 1915, p. 205.

Atlantic City in June, 1914, that of the two factors, namely, the ureteral peristalsis and the mechanism of the ureterovesical valve, the peristaltic factor is often the vitally important one in the determination of a possible renal infection. Furthermore, it was shown that when this ureteral function was seriously impaired, amounting virtually to a ureteral paralysis, and the ureterovesical valve function was left intact,

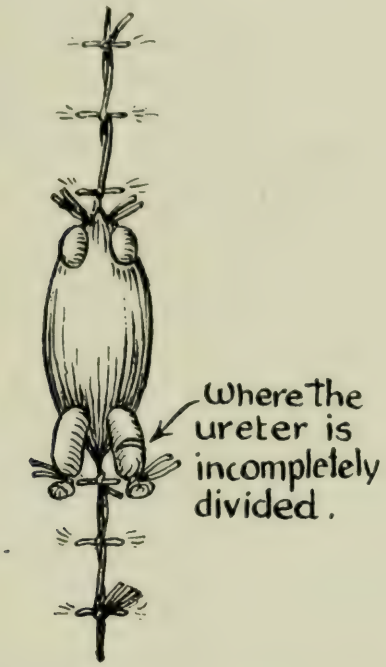

Fig. 4.—Distended ureteral ends.

hydronephrosis followed in 75 per cent. of cases.[15] The latter experiments have been repeated during the past fall with the following results:

In Dogs 16 and 17, the infected vesical body had become a urethral calculus. The expected results followed in a more accentuated form, but because of this new variant, these experiments have been omitted from consideration.

Dogs 6 and 22 are negative.

Of the remaining, 50 per cent. are hydronephrotic and 83⅓ per cent. are hydronephrotic or have dilated ureters. These results may be seen to compare favorably with those already referred to.

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15. Stewart and Barber: Hydronephrosis: An Experimental Study, Ann. Surg., December, 1914.

Hence, it appeared that an operation to have substantial functional value must, above all, involve the least possible traumatization of the ureter. Furthermore, it must be granted that some degree of traumatization is inevitable and that its peristaltic efficiency is proportionately impaired. Therefore the caudad resistance must be proportionately decreased if the ureter is expected to empty itself. For this reason, not only the resistance of a normal valve appeared too great, but also all resistance arising from artificially created plastics appeared too great. The problem then remains: How anastomose the ureters with the lower bowel with the least interference with their peristaltic function and with the establishment of caudad resistance physiologic for them in their necessarily impaired states?[16]

The following operation represents an attempt to correlate the experience of others with the recently obtained physiologic knowledge of the ureter:

A mesoventrad incision is made in the lower abdomen. The bladder is drawn toward the wound. One or both ureters may be created as follows: identify, doubly ligate, and cut between ligatures; attach a large, straight cutting needle to the cephalad end by its ligature, and penetrate the sigmoidal wall in the plane of the mesenteric reflection. Drive the needle with the aftercoming ureter obliquely for from 1.5 to 2 cm. through the wall, with the colon held on the stretch. At a point approximately 1 cm. obliquely distant from the point at which the needle enters the lumen of the sigmoid, penetrate the colon perpendicularly, drawing the ureter out on the skin. Suture the ureter to the skin by its ligature and close the wound about that part of the sigmoid traversed by the ureter. It is of advantage to strip the ureter in its caudad one fourth and to free the distal two fourths digitally to avoid angulations, torsion or harm-

16. Barber: Uretero-Enteric Anastomosis, Ann. Surg., March, 1915. In addition to the foregoing references, the following may be consulted:
Reynolds, Edward: A Case of Vesical Implantation of the Ureter by Dudley's Forceps Method After Failure of Several Plastics, Boston Med. and Surg. Jour., Jan. 24, 1901.
Cabot: Am. Jour. Med. Sc., 1892, ciii, 43.
Harrison: Lancet, London, 1897, p. 1091.
Matas: Treatment of Exstrophy of the Bladder by Making a Receptacle for the Urine out of the Lower Cecum, Utilizing the Appendix for the Urethra, Zentralbl. f. Chir., Aug. 13, 1910.
Thomson: Ztschr. f. Geburtsh. u. Gynäk., 1893, p. 173.
Bottomley, J. T.: Operative Treatment of Exstrophy of the Bladder by Transplantation of the Ureters on to the Skin of the Loin, The Journal A. M. A., July 13, 1907, p. 141.
Berg: Treatment of Exstrophy of the Bladder, Nord. Med. Ark., Surg. Sect., 1907, No. 1.

ful tension. It is important to see the ureteral ends distended before the closure of the abdominal wound in order to make certain that the urine flow is not obstructed. It is convenient to divide the ends incompletely to free the urine after completion of the operation, although this may be delayed six hours apparently without resultant ureteral or renal injury.

TABLE 1.—REPORT ON SECOND SERIES OF URETERAL TRAUMATIZATION, DEC. 7, 1914

Dog No.	Days of Life	Pathologic Condition of Urinary Tract
23	50	Dilatation of cephalad ureter cystitits
6	23	Purulent cystitis
16	12	(Abdominal organs negative.) Left hydronephrosis; hydro-ureter; pyelonephritis. Right pyelonephritis. Sup. cystitis; acute vesical retention; urethral calculus.
14	15	Left hydronephrosis; cystitis
17	15	Cong. kidneys. Left hydro-ureter; cystitis; urethral calculus
13	15	Cong. kidneys; cystitis. Dil. of cephalad ureter
15	14	Left hydronephrosis; cystitis
24	9	Left hydro-ureter; hydronephrosis; cystitis
80	21*	Left hydronephrosis; cystitis
82	11	Left pyonephrosis; hydro-ureter; cystitis
5	50*	Left dil. of cephalad ureter; cystitis
22	10*	Negative
83	20*	Left hydro-ureter
81	16	Left hydronephrosis; hydro-ureter; cystitis

* Etherized.

The technical results of this procedure may best be appreciated by a review of the experimental series tabulated herewith.

The following points with reference to Tables 1 and 2 are noteworthy:

1. The results of the preceding operations are operative only, for none of the animals received postoperative surgical attention.

TABLE 2.—SUMMARY OF EXPERIMENTAL DATA INCIDENTAL TO A STUDY OF URETERO-ENTERIC ANASTOMOSIS

1. Unilateral Transplantation

Dog No.	Technic	Duration of Ex. in Days	Pathologic Condition	Conclusion
311	Maydl	4	Sloughing of transplant; peritonitis	Technical failure
299	Maydl	3	Ureteral stenosis; soiling; peritonitis	Technical failure
19	Direct anastomosis to aboral end of cephalad third of colon; ureter traumatized	6*	Caudad stenosis; hydro-ureter; hydronephrosis; marked injection of colon	Plus caudad ureteral resistance; oral colon intolerant to urine
33	Oblique anastomosis for 0.5 cm. to caudad third of colon	7*	Omental adhesions; hydro-ureter; hydronephrosis	Plus extra-ureteral resistance
34	Direct anastomosis	26	Caudad stenosis; hydro-ureter; hydronephrosis	Plus caudad resistance
45	Oblique; 0.5 cm. to caudad colon; least traumatization of ureter	26*	Caudad stenosis; hydro-ureter; hydronephrosis	Plus caudad resistance
46	Direct; ureter traumatized	5	Necrosis of ureter from overtension; hydro-ureter; hydronephrosis	Plus caudad resistance
47	Oblique; least traumatization of ureter	5*	Caudad stenosis; hydro-ureter; hydronephrosis	Plus caudad resistance
50	Oblique; 0.5 cm.; least traumatization; digital freeing of ureter	17	Caudad stenosis; hydro-ureter; pyonephrosis	Plus caudad resistance
51	Direct; traumatization	32	Caudad stenosis; hydro-ureter; hydronephrosis	Plus caudad resistance

92	Direct; least traumatization.....	3	Leakage from right; caudad stenosis in left	(Right) compression and sloughing. (Left) plus caudad resistance
109	U-catheter used	4	Perforation by catheter; peritonitis...	Stiff catheter dangerous
136	Oblique; least traumatization.....	?	(Records incomplete).....	
137	Catheters used; oblique.....	?	Sloughing of ureter; peritonitis.....	Overtension of ureter
130	Oblique; traumatization	7	Left dilated ureter; kidney congested. Right plus dilated ureter; edematous kidney	Caudad resistance less, but still plus physiologic
147	Oblique; 1 cm.....	9	Pneumonia. Left ureter distended. Right ureter dilated slightly caudad	Anastomosis well balanced
178	Oblique; 1.5 cm.; digital freeing...	5	Ureters dilated cephalad; pelves dilated; kidneys edematous	Resistance too great for impaired ureters
186	Oblique; 1.5 cm.....	7	Left ureter dilated plus cephalad; pyonephrosis. Right ureter dilated slightly cephalad; kidney normal	1.5 cm. adequate resistance
187	Oblique; 1.5 cm.....	9	Left ureter dilated cephalad; pelvis dilated slightly. Right ureter dilated caudad	1.5 cm. adequate resistance on left side; ? on right side
188	Oblique; 1.5 cm.....	10	Ureters left intact on skin; therefore:	Resistance plus
199	Right oblique; 2 cm.; freeing of caudad third. Left direct	17	Right normal ureter and kidney. Left pyonephrosis	Right; resistance adequate Left; resistance plus

* Etherized.

2. Plus physiologic caudad ureteral resistance is manifested first by dilatation of the cephalad end of the ureter.

3. Continued incomplete ureteral obstruction leads to a dilatation of the second and third portions of the ureter and a dilatation of the renal pelvis.

4. Direct ureterosigmoidal entrance is more obstructive than the oblique entrance and the more oblique (from 1 to 2 cm.) the less that obstruction.

Fig. 5 (Dog 199 B 2).—Left kidney with foci of infection and right kidney normal fourteen days after transplantation of left ureter perpendicularly and right ureter obliquely for 2 cm. into sigmoid. Note sacculation of sigmoid with caudad ends of ureter firmly embedded in its mesenteric wall.

CONCLUSIONS

1. Ureterosigmoidal plastics are tedious for the operator and unsafe for the patient.

2. Operations in which the caudad ends of the ureters are allowed to protrude freely or fixedly

within the sigmoid are meritorious in so far as the intramural portions of the ureters are unobstructed. Time spent in elaborating the terminal relations of the ureters is therefore valueless.

3. Oblique entrance from 1.5 to 2 cm. and the least foreign substance including blood and injured tissues are conducive to the least reactive inflammatory occlusion of the intramural portions of the ureters. These are most conveniently accomplished by the needle and ligature.

4. By leaving the ureterosigmoidal field exposed, an enteric diverticulum is formed for urinary storage, and the ureters remain accessible to investigation if desirable.

104 East Fortieth Street.

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DECEMBER, 1917.

DISCUSSION ON INGUINAL HERNIA

DR. WILLIAM C. LUSK said that little was ever said of the importance of the transversalis fascia in the repair of inguinal hernia. Transversalis fascia normally occupied the whole floor of the inguinal canal and in indirect inguinal hernia the opening in this fascia through which the hernia came was perhaps the only part of the inguinal canal that actually needed repair and reinforcement. In order to guard against recurrence at the internal ring in these herniæ, Dr. Halsted had laid down the principle that the transversalis fascia should be dissected away from the sac at the internal ring so that, in tying off the sac, only peritoneum would be included in the ligature and the stump could then retire behind the abdominal wall. Should, however, the transversalis fascia overlying the neck of the sac be left *in situ* and be included within the grasp of the ligature that tied off the sac, it could be seen that by thus leaving the stump of the sac to protrude through the internal abdominal ring, a source of weakness would be introduced at the very situation where a careful reconstruction of the layers of tissue was needed. When, in operating for these herniæ, the neck of the sac had been tied off independently of its fascial connections and its stump had receded well within the internal ring, then it was that by transplantation of the cord with external displacement of the same into the outer angle of the inguinal canal, which manœuvre coincidently drew into an extreme outward position the transversalis fascia attached to the cord, the opening at the internal ring was automatically closed.

Dr. Lusk said that for the repair of direct herniæ he practised Dr. Halsted's operation of taking a flap from the anterior layer of the rectus sheath and sewing it to the inner portion of Poupart's ligament. Dr. Halsted did not transplant the rectus muscle. Dr. Lusk had illustrated the cutting of a rectangular flap from the anterior layer of the rectus sheath for the repair of direct hernia in the ANNALS OF SURGERY, November, 1913, p. 677. The anterior layer of the rectus sheath was unyielding; the posterior layer of the rectus sheath contained some slack. By cutting the rectangular flap in the anterior layer of the rectus sheath, the horizontal arm of the flap cutting well out to, but not through, the outer border of the rectus sheath, and the vertical arm cutting downward to the pubic spine, the restraint exercised by this layer of the rectus sheath on the arched fibres of the internal oblique and transversalis muscles was freed and the slack

of the posterior layer of the rectus sheath given play, so that both the arched fibres as well as the rectangular flap could be readily brought down and sutured to Poupart's ligament without tension. The horizontal arm of the rectangular flap should be made about 1¼ inches above the pubic spine.

For protection against recurrences which came as a result of suppuration, Dr. Lusk recommended the use of MacDonald's solution for disinfection of the skin instead of tincture of iodine. The wounds for inguinal herniæ, being through hairy parts, were particularly difficult to disinfect. The tincture of iodine containing no fat-solvent could not reach bacteria embedded in greasy particles, but MacDonald's solution containing the fat-solvent acetone, by liquefying the grease, liberated the bacteria imprisoned therein, thus exposing the latter to the action of the disinfectant ingredient of the solution. The formula was 40 parts acetone, 60 parts alcohol, to which 2 per cent. pyxol was added. His own experience, and the reported results of some others, spoke for the superiority of MacDonald's solution over tincture of iodine for skin disinfection.

NEUROTIZATION OF PARALYZED MUSCLE BY MUSCLE GRAFTING

A LABORATORY AND CLINICAL STUDY *

JOHN JOSEPH NUTT, M.D.
NEW YORK

This study was undertaken for the purpose of determining whether function could be returned to a muscle paralyzed by poliomyelitis, through the growth into it of nerves from a neighboring sound muscle. This neurotization I proposed to accomplish, not by implanting a sound nerve directly into the body of the paralyzed muscle, but by splitting the sheaths of both the normal and the paralyzed muscles, scarifying the fibers so as to remove all obstruction offered by the sarcolemma to the growth and extension of nerves, and then suturing the open surfaces of the two muscles together.

It has been my experience in one or two instances that after the transplantation of the biceps to do the work of the paralyzed quadriceps there has followed some return of power to the paralyzed muscle. This may have been the result of unintentional muscle grafting.

In a personal communication, Sayre has informed me that in 1898, after an operation for paralysis in which all the anterior muscles of the foot were affected, with the exception of the extensor longus pollicis, he had a result which could not have been due entirely to the operation unless he unknowingly did more than he had planned. He performed the Parrish operation[1]: a fusion of the tendons of the tibialis anticus and the extensor longus pollicis, operating

* Read before the Society of Alumni of Bellevue Hospital, Oct. 3, 1917.

1. Parish, B. S.: A New Operation for Paralytic Talipes Valgus and the Annunciation of a New Surgical Principle, New York Med. Jour., 1892, **56**, 402.

above the annular ligament, and, through the incision, he had made a careful examination of all the other muscles. Much to his surprise, power returned to the extensor communis digitorum. It is possible that he destroyed the intermuscular septum and the sarcolemma sufficiently to permit a muscle grafting.

In June, 1905, Gersuny[2] grafted the deltoid to the trapezius for a shoulder paralysis. The patient was a young man and the cause of the condition is in

Fig. 1.—Muscle paralyzed by poliomyelitis. Fibers shrunken as in atrophy from disuse.

doubt. After three months there was a slight return of movement. During the following months, improvement continued until in November the arm could be used normally except for the fact that it was still weaker than the other arm.

In February, 1907, von Hacker[3] operated for paralysis of the shoulder which followed an operation for tuberculous glands of the neck. His muscle grafting

2. Gersuny: Wien. klin. Wchnschr., 1906, **19**, 263.
3. Von Hacker: Mitt. d. Ver. d. Aerzte in Steiermark, 1908, **45**, 58.

was at least partially successful, as the patient could lift the arm to the horizontal five months later.

The neurotization of paralyzed muscle by nerve implantation has been done by several surgeons.

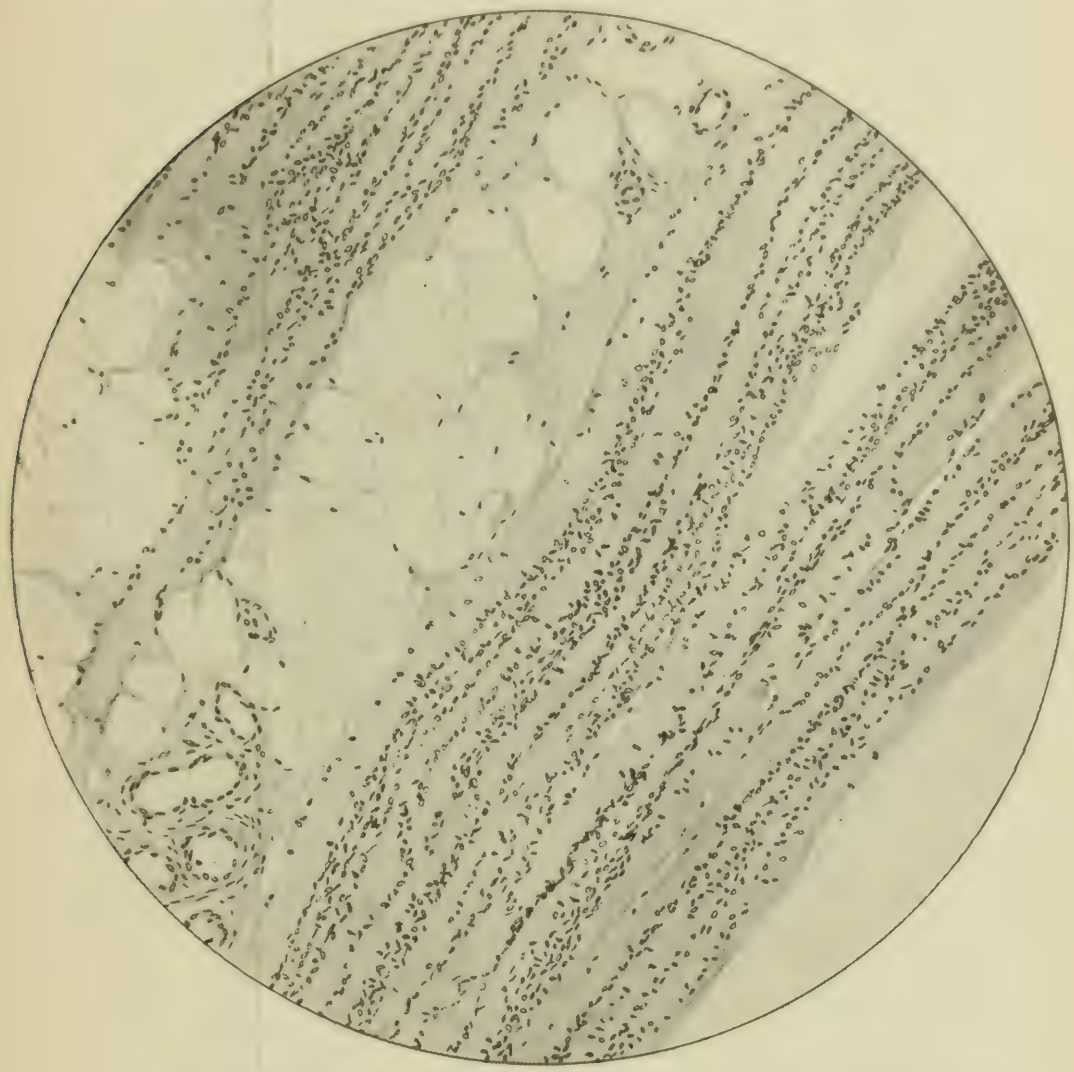

Fig. 2.—Muscle paralyzed by poliomyelitis. The great number of nuclei show that an unsuccessful attempt at regeneration has been made. Striations are absent; fibers are shrunken, and fat is deposited between them.

Heineke[4] has reported successful experiments, and Erlacher[5] has not only reported successes but claimed

4. Heineke: Zentralbl. f. Chir., 1914, **41,** 465; Arch. f. klin. Chir., 1914, **105,** 517-523.

5. Erlacher: Ztschr. f. orthop. Chir., 1914, **34,** 561; Zentralbl. f. Chir., 914, **41,** 625; Am. Jour. Orthop. Surg., 1914-1915, **13,** 22.

that hyperneurotization is possible. Steindler[6] of Iowa City has been successful in neurotizing paralyzed muscle by the implantation of sound nerves, but he does not believe it possible to hyperneurotize a muscle. Elsberg[7] has determined a remarkable fact, namely, that if an artificially paralyzed muscle is implanted with its original nerve and also another motor nerve,

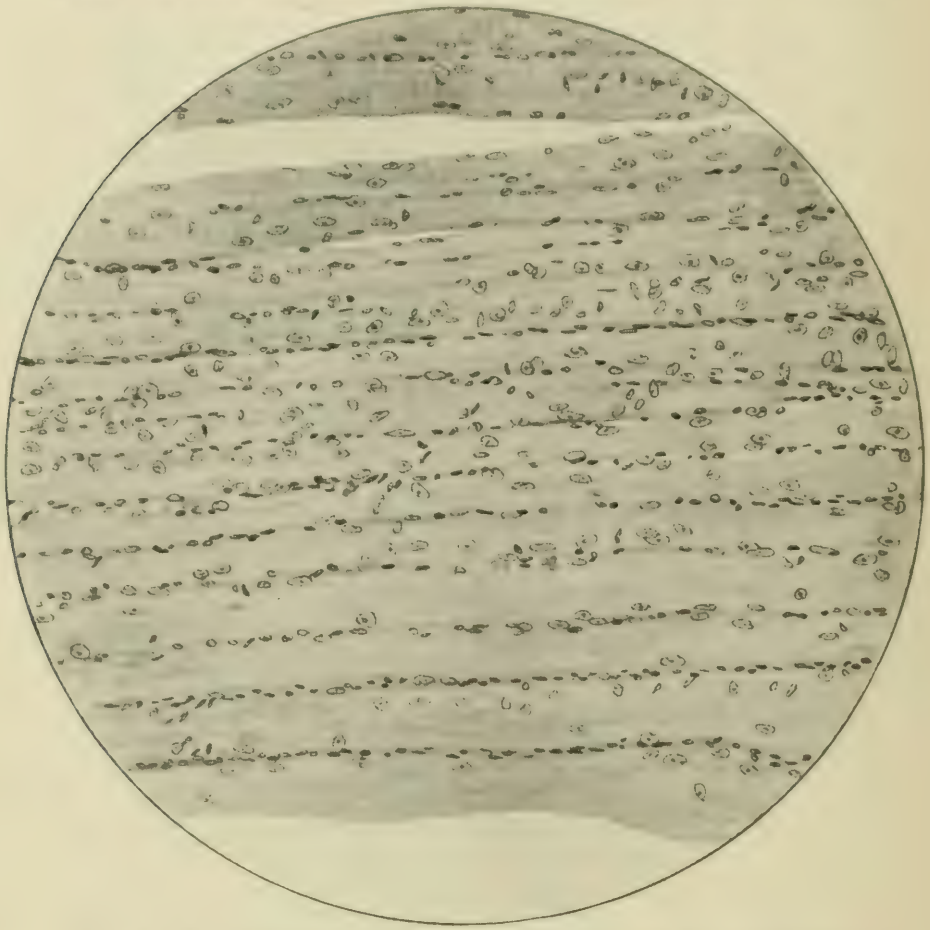

Fig. 3.—A successful attempt at regeneration in a dog. Fibers are compact, and striations may be seen.

reestablishment of function takes place through the original nerve and not through the foreign nerve. On the other hand, if the original nerve were not implanted, the foreign nerve would take up the work. He agrees with Steindler that hyperneurotization is impossible. He also found that eight weeks of paralysis produced the characteristics of atrophy, and that

6. Steindler: Am. Jour. Orthop. Surg., 1914-1915, **13**, 33; ibid., 1916, **14**, 707.
7. Elsberg: Science, New York, 1917, **45**, 318.

eight weeks after nerve implantation, normal appearance was regained and good contraction established. He reports several successful neurotizations, in which he transplanted a portion of the sound muscle with the nerve. Gerster and Cunningham[8] report successes with nerve implantation.

By experimenting on dogs, I have sought to inform myself regarding paralytic changes in muscles and

Fig. 4.—Nerves growing from paralyzed muscle above into paralyzed muscle below. Their dotted appearance and the straightness of their course are characteristic of new nerve growth.

also the changes which take place as a result of muscle grafting. This part of the work has been carried on in the Department of Experimental Surgery of the New York University and Bellevue Hospital Medical College. The histologic studies have been made by Dr. Alexander Fraser of the pathologic department.

The anterior tibial and the sciatic nerves were selected for section in the work on dogs. After an

8. Gerster and Cunningham: Med. Rec., New York, 1917, **92**, 23.

interval following the former operation and varying from two to six weeks, the paralyzed tibialis anticus muscle was grafted to the normal peroneus. After resection of a portion of the sciatic, the vastus externus was grafted to the paralyzed biceps.

Figure 1 shows atrophy in a specimen taken from a case of poliomyelitis. The same characteristics would be present in an atrophy from disuse. If there is absolute separation of a muscle from all nerve supply, a condition seldom obtained and perhaps impossible to obtain except in the case of the external rectus of the eye, the fibers undergo fatty degeneration. In atrophy from poliomyelitis, however, the muscle fibers are shrunken, and the nuclei increased, and there is no evidence of fatty degeneration.

Figure 2 shows an unsuccessful attempt at regeneration. The great number of nuclei testify to the activity of the endeavor, but there are no striations of fibers.

Figure 3, obtained from a dog, illustrates the successful attempt at regeneration. Note the nuclei, the striations and the compactness of the fibers.

Figures 4 and 5 show the growth of nerves from the sound muscle into the paralyzed muscle.

Figure 6 shows an end plate which in all probability is from the new nerve growth following the grafting operation.

The last three specimens were taken from a dog six weeks after the grafting operation and nine weeks after the artificial paralysis.

The operations on patients have been performed at the State Hospital for the Care of Crippled and Deformed Children and at the College Clinic. Specimens were taken and examined by Fraser from all of the clinical cases except six. The extent of atrophy was found not to be commensurate with the time since the attack, but to depend on the completeness of the paralysis. Loss of function may be complete in two muscles, and yet one of them may have sufficient nerve supply preserved to prevent the complete atrophy experienced by the other. Electricity has not helped me in estimating the extent of the paralysis, that is, the extent of the nerve supply remaining after the easily demonstrated loss of function. The discovery of some method of ascertaining the exact condition of the muscle before operation is greatly to be desired.

It is quite obvious that any attempt to regenerate a muscle which has lost all trace of muscle fiber would be futile. This was true in several of the patients operated on. They are all reported as cases of muscle grafting, since I finished the operations as nearly as possible as originally planned.

The operation is done as follows: An incision is

Fig. 5.—Another section showing new nerve growth.

made to bring into the field the bellies of the two muscles. Both are split lengthwise. The deeper edges of the two opened surfaces are sewed together with chromicized catgut. A few interrupted sutures are so placed as to approximate the central parts of the two freshened surfaces, and then the upper edges of the cuts are sewed together. The skin wound is then closed.

It will be seen that even if nothing is gained by such an operation, nothing is lost. No function is sacrificed, as is the case in such operations as muscle transplantation, tendon fixation and nerve implantation. The objection to early operation, which is so valid in all other procedures, does not hold good for this operation.

Sixteen cases, all I had done up to August, are here reported in the order of operation. In four of them, two paralyzed muscles each were operated on, making a total of twenty muscle graftings. Seven were complete failures, although one of these was operated on as recently as July 27 and may yet prove to be of some

Fig. 6.—An end plate from a muscle-grafting specimen, in all probability from the new nerve growth.

value. Six patients show a slight return of power, which, however, is by no means sufficient to be of functional use. This slight power, as we know from similar results in muscle transplantation, may add to the strength of the joint and thus be of some benefit. Four cases have given fair results and three good results. The last seven cases give us the courage to report our work at this time, although we fully realize that much more will have to be done in both the laboratory and the clinic before the operation should be either unconditionally accepted or discarded.

REPORT OF CASES

Case 1.—C. B., aged 15, was operated on, Dec. 15, 1915, after an attack occurring nine years before. The normal gastrocnemius was grafted to the paralyzed peroneus longus. There was no return of power.

Case 2.—J. D., aged 18, was operated on, Dec. 11, 1916, after an attack in early childhood. The normal soleus was grafted to the paralyzed peronei.

The result was good, as the peronei can now contract and the foot can be abducted.

Case 3.—G. B., aged 14, was operated on, Feb. 12, 1917, after an attack occurring five years previously. The normal peroneus longus was grafted to the paralyzed extensor communis digitorum.

The result was good, as it was estimated that there was a return of fully half the muscle's normal power. A second operation was performed, March 18, when the normal biceps was grafted to the paralyzed vastus externus.

The result was slight, as the patella can now be moved upward and outward in attempts to extend the leg, and, with the opposition of gravity removed, extension is possible.

Case 4.—E. N., aged 9, was operated on, Feb. 12, 1917, after an attack occurring at the age of 3. The normal tibialis anticus was grafted to the paralyzed extensor longus pollicis. There was no return of power.

Case 5.—B. S., aged 13, was operated on, Feb. 23, 1917, after an attack occurring seven years previously. The normal peroneus longus was grafted to the paralyzed extensor communis digitorum. There was a slight return of power.

Case 6.—J. M., aged 10, was operated on, Feb. 23, 1917, after an attack occurring four years before. The normal extensor longus pollicis was grafted to the paralyzed extensor communis digitorum. The result was good, as fully half the normal power was restored.

Case 7.—H. B., aged 9, was operated on, March 7, 1917, after an attack occurring six years previously. The normal extensor longus pollicis was grafted to the paralyzed tibialis anticus and the normal soleus to the paralyzed tibialis posticus. There was no return of power.

Case 8.—M. M., aged 4, was operated on, March 12, 1917, after an attack occurring ten months previously. The normal biceps was grafted to the paralyzed vastus externus. A fair result was obtained with the opposition of gravity removed; the patient can extend his leg.

Case 9.—J. C., aged 2, was operated on, March 12, 1917, after an attack occurring one year previously. The normal tibialis anticus was grafted to the paralyzed extensor communis digitorum, and the normal flexor longus digitorum to

the paralyzed soleus. The result was a fair return to the extensor communis digitorum, and a very slight return to the soleus.

Case 10.—M. H., aged 6, was operated on, March 15, 1917, after an attack occurring one year previously. The normal extensor longus pollicis was grafted to the paralyzed tibialis anticus. The result was a slight return of power.

Case 11.—H. McC., aged 9, was operated on, March 23, 1917, after an attack occurring one year previously. The normal peroneus longus was grafted to the paralyzed extensor longus digitorum. There was no return of power.

Case 12.—R. L., aged 9, was operated on, April 1, 1917, after an attack occurring seven years previously. The normal biceps was grafted to the paralyzed vastus externus.

There was a slight return of power, so that the patient can now extend his leg, with the opposition of gravity removed.

Case 13.—E. H., aged 11, was operated on, May 3, 1917, after an attack occurring at the age of 2. The normal peroneus was grafted to the paralyzed soleus, and the normal extensor longus pollicis to the paralyzed tibialis anticus.

Fair results were obtained in the tibialis anticus and none in the soleus.

Case 14.—M. E., aged 12, was operated on, May 7, 1917, after an attack occurring in early childhood. The normal peroneus longus was grafted to the paralyzed soleus. The result was fair, as the muscle now contracts with perhaps half its normal strength.

Case 15.—W. L., aged 12, was operated on, July 27, 1917, after an attack occurring five years previously. The normal extensor longus pollicis was grafted to the paralyzed tibialis anticus. The result was a slight return of power.

Case 16.—R. S., aged 5, was operated on, July 27, 1917, the time of the attack being unknown. The normal extensor longus pollicis was grafted to the paralyzed tibialis anticus. There was no result.

Fifty-Fifth Street and Seventh Avenue.

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A METHOD FOR OBTAINING UNCONTAMINATED BLOOD FROM DOGS AND OTHER ANIMALS

BY CHARLES GOODMAN, M.D.
OF NEW YORK
PROFESSOR OF CLINICAL SURGERY IN THE NEW YORK UNIVERSITY

(From the Laboratory of Physiological Surgical Research, New York University, and the Laboratory of Physiological Chemistry, Beth Israel Hospital)

SEROLOGY has become one of the important features of modern medicine, and is at present receiving close attention from laboratory workers. Our experiments in vascular surgery and transplantation entailed a series of serological studies, and we were confronted at the outset with great difficulties in obtaining specimens of blood from the animals without having them prove worthless for the object of the experiments. This was due to contamination or laking. These obstacles were preëminent in dogs, whose blood coagulates very quickly. On account of the fragility of the erythrocytes in this animal, the blood is handled with difficulty. Peyton Rous at a recent meeting of the Society of Biology and Experimental Medicine stated that he had overcome this inconvenience by the addition of one-eighth of 1 per cent. of gelatin to the specimen. We were unable to make use of this suggestion as it was necessary to utilize serum which was free from foreign substances.

Following the suggestions made by Besson,[1] I had attempted to obtain specimens of dog's blood from the saphenous vein, femoral vessels, the carotid and external jugular. In some instances I obtained specimens from the vein following the margin of the outer side of the ear.

After various efforts with syringes, different cannulas and aspirating needles, I found that blood obtained by a simple glass cannula introduced into the jugular vein gave us the most satisfactory results.

Among the different methods tested was aspiration of the ventricles. This required general anæsthesia in a dog and was attended with great danger to the life of the animal. The following method

[1] Besson, A.: Practical Biology, Microbiology and Serum Therapy. Fifth Edition. Translated by H. J. Hutchins. Longmans, Green and Co., Publishers, 1913, London and New York.

was devised which is exceedingly simple in its application and we wish to report its successful use in 10 consecutive experiments.

Technic.—The dog may be given a preliminary hypodermic of morphine. The external jugular was then exposed under local anæsthesia of novocaine (½ of 1 per cent.). This anæsthesia was very easily carried out in dogs. Two provisional ligatures were now passed around the vessel for the purpose of controlling the circulation. Two serrefines or flexible blood-vessel forceps might be

FIG. 1.

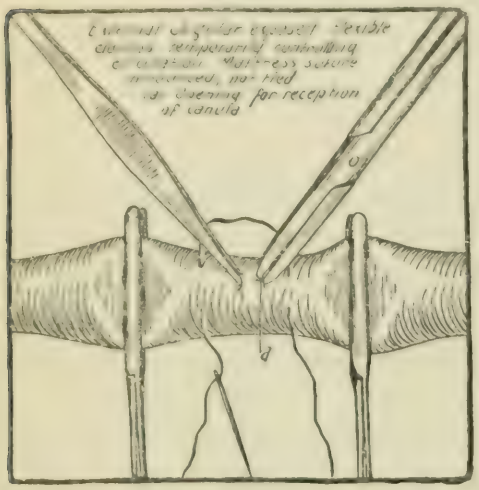


FIG. 2.

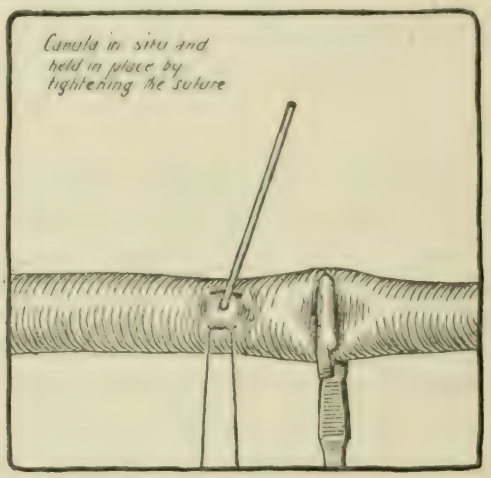
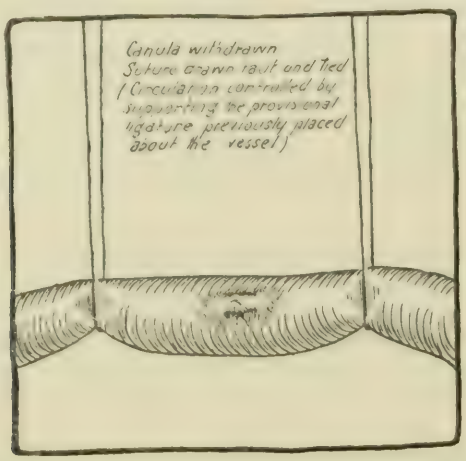


FIG. 3.



employed for the purpose. A square mattress suture of silk threaded on a fine cambric needle was passed through all the coats of the vein. An opening was made in the vein between the two arms of the mattress suture and a small glass cannula previously sterilized was inserted (without paraffin). The suture was now tightened by a slip or bow knot securing the cannula in the vessel. One of the provisional ligatures or serrefines was then relaxed, permitting the blood to flow through the cannula into the sterile test-tube or container. After the desired quantity of blood had been collected, the cannula was withdrawn and the mattress suture was drawn taut and tied. The suture approximated intima to

intima, and the wound healed without thrombosis. This little operation was completed by one or two sutures introduced into the skin. By the use of this method, various quantities of blood were obtained from the same vein at varying intervals without any evidences of thrombosis or interference with the circulation of the vessel. In order to obtain a perfectly clear serum, at the suggestion of Professor A. R. Mandel of the New York University, the tubes containing the blood were immediately placed in a dish of cracked ice. At the end of from 20 to 30 minutes, the plasma was drawn off with a pipette and later the supernatent serum was removed by the same method. The serum obtained was then centrifuged.

By this method invariably large quantities of clear serum were obtained free from corpuscles, bacteria or other contamination.

This method has greatly facilitated the work.

Thanks are due Drs. I. Seff and S. Berkowitz who assisted me in this work.

HEMOLYSIS AND AGGLUTINATION IN TRANSPLANTATION *

CHARLES GOODMAN, M.D.
Fellow of the American College of Surgeons; Professor of Clinical Surgery, University and Bellevue Hospital Medical College
NEW YORK

In studies of the conditions incident to the cause of autolysis and the dissolution of the transplant, we devoted especial attention to the influence of hemolysis and agglutination on transplants. No question is more timely than that concerning the causes of their absorption.

Most authors lay great stress on the importance of eliminating the two great dangers in blood transfusion — hemolysis and agglutination. We must consider blood transfusion not only as an infusion of a certain quantity of fluid, but also as a transplantation of a definite mass of tissue represented by the cellular elements of the blood.

Accordingly, before transplanting the thyroid, we first made hemolysis and agglutination tests, and operated only when these reactions were absent.

Owing to difficulties in obtaining and in handling the blood (which have since been obviated to some extent by a new method), we are thus far able to report results in only seven instances.

Before the employment of these tests, we were unable to obtain any results from homotransplantation. But since the importance of these reactions came to be more clearly appreciated, we have in two instances, at least, obtained a satisfactory preservation of the transplant for one and three weeks, respectively. While our experiments have been few in number, we feel justified in concluding from results so far obtained that the hemolysis and agglutination tests to a certain

* From the Laboratory of Physiological Surgical Research, University and Bellevue Hospital Medical College, and the Laboratory of Physiological Chemistry, Beth Israel Hospital.

HEMOLYSIS AND AGGLUTINATION

Date	Donor	Host	Hemolysis	Agglut.	Remarks
1/22	179	180	Negative	Negative	In this instance there was autolysis and absorption in three months.
2/3	190	191	Partial	Negative	Thrombosis of the artery set in in six weeks.
2/17	201	202	Negative	Negative	The results were good after eight days.
3/10	224	225	Negative	Negative	The results were good after three weeks.
3/12	228	229	Negative	Negative	Hemorrhage set in in two weeks.
3/20	215	239	Negative	Negative	
4/9	281	282	Negative	Negative	

extent are some indication of the tolerance of the tissues of one animal for those of another. Such a hypothesis is given some support by the fact that in blood transfusion these reactions are now largely depended on as clinical indicators. May they not therefore be reasonably expected to be of equal significance in the transfer of the less liquid tissues from one organism to another?

Thanks are due to Dr. Samuel Berkowitz for valuable assistance.

969 Madison Avenue.

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TWO CASES OF THORACIC ANEURISM WIRED FOUR YEARS AND THEREABOUTS AGO RESPECTIVELY*

WITH REMARKS ON THE ANTISPECIFIC TREATMENT AND THE OPERATIVE TREATMENT OF THORACIC ANEURISM

By William C. Lusk, M.D.
of New York City

PROFESSOR OF CLINICAL SURGERY IN THE NEW YORK UNIVERSITY AND BELLEVUE HOSPITAL MEDICAL COLLEGE AND ASSISTANT VISITING SURGEON, BELLEVUE HOSPITAL

The following two cases of thoracic aneurism were presented before the New York Surgical Society two years and a half ago (Annals of Surgery, lix, 1914, p. 461, Cases II and III). Both cases after the wiring operation were given antispecific treatment, and they developed an ability to endure very severe exertion. Special attention is called to the need for treatment of aneurism with the antispecific remedies, which the writer believes should be administered in the way herein described in order to get good results.

Case I.—V. A., bar-tender, present age forty-two. Referred by Dr. A. de Yoanna. The Moore-Corradi operation of wiring with electrolysis was performed on May 3, 1912. The patient had had pain for about one year prior to operation, which, from a time three months before operation for a period of one month, had been so great that he could not sleep. Just before the operation there was a steady pain in the right axilla and in the inner side of the right arm. The aneurism had eroded through the right second costal cartilage. Pulsation was not very forcible. No bruit. No respiratory symptoms. For a month prior to coming to the hospital he had been given mixed treatment with no apparent benefit.

At *operation* seventeen feet of the "clasp" gold wire No. 29, shaped in evenly curved loops from 4½ to 5½ inches in diameter, were introduced into the aneurismal cavity through an insulated gold needle. The electric current used was 100 ma. for seventeen minutes and 50 ma., 40 ma., and 30 ma., each for fifteen minutes. After thirty-five minutes of the electrical séance the pain had entirely subsided. During convalescence the pains were intermittent and of short duration. In the course of a month following the operation there was practically no pain unless from too much exertion. At the end of two months the patient could walk three or four short blocks without pain. He worked all that

* Cases presented before the New York Surgical Society, May 10, 1916.

summer tending bar, having very little pain and that only occasionally. Antiluetic treatment was at first withheld in order to test the efficacy of the wiring operation of itself to relieve the pain. He began taking mixed treatment the end of May, 1912, and took the same pretty regularly until the following March. He thought when the mixed treatment was interrupted that he would have more pain, which would seem to leave again on his return to the medicine. With excessive exertion he would have a temporary return of pain. On February 26, 1913, it is recorded that he was daily walking up one flight of stairs four or five times, was on his feet seven or eight hours, was walking four to five blocks and suffering no pain. This was before he was given salvarsan. Between March 31 and November 28, 1913, he was given four injections of neosalvarsan, two of 0.3 g. and two of 0.45 g., two injections of salvarsan 0.3 g. and eleven intramuscular injections of the salicylate of mercury, in the course of which treatment his activity was greatly increased. On September 11, 1913, it is recorded that each day he would stand all day working as bar-tender, would lift 30 to 40 pounds about once and would walk about two miles. About twice a week he would have a little pain following exertion lasting about five minutes. On November 18 of the same year, he stated that a quick walk for half a mile had excited a little pain. In the winter of 1913–1914 he and his brother, who also had a thoracic aneurism which was wired by the writer, went to Brazil, where for seven months they both peddled suits of clothes, carrying the same in packs on their backs, walking about six miles every day, stopping from house to house, being thus engaged about six to seven hours a day, each carrying a pack weighing at the beginning of the day about 50 pounds. Neither of them had any pain during this time. They were some of the time at Rio Janeiro, which is a hilly city. In the fall of 1914, while in Italy, two or three times this patient walked six or seven miles on the level without pain or any difficulty. In the past fifteen months (prior to May 10, 1916) he has been the proprietor of a restaurant in a neighboring city, and has done no particularly hard labor. He walks habitually twelve blocks a day and on Sundays he walks about two miles slowly. In the past fifteen months he has had no pain in the right side of his chest, except three months ago he had an attack of pain in this locality as well as in the right upper extremity lasting about two minutes accompanied by dizziness and pallor, and two weeks ago he had a second similar attack lasting three or four minutes. During the past winter every day he carried up two pails of coal from the cellar, two flights, one pail in either hand, each weighing about 25 pounds. There was no ill effect from this work. In the winter of 1913–1914 he took a

bottle and a half of mixed treatment and in the spring of 1915 three bottles more. He has had no treatment since. His Wassermann, at first negative, in April, 1913, was found to have become positive and in September, 1913, was very strongly positive. In over two years the patient has been seen only twice by the writer.

Case II.—G. S., machinist, present age fifty-two years. Referred by Dr. Leon T. LeWald. In March, 1910, he began to have pains in his chest. In April, 1911, he noticed a lump in his chest and the pain became continuous day and night in the front and back of the left side of his chest and in his left arm. The pain was very severe so that he could hardly sleep and he groaned with the pain. In June, 1911, he went to a hospital where as a result of resting and the taking of potassium iodide for four weeks, he improved so much that he was able to return to work on a radial drill, at which employment he then continued until July 3, 1912. During this time he had pain only when he worked, but not at night until about the middle of June, 1912, when the pain came on at night as well, but was not so severe as it had been the previous year. In fact, at that time he was able to sleep four or five hours at night. He had no shortness of breath. He had to scrape his throat a little. The aneurism could be readily felt pulsating in the left second and third intercostal spaces as far as to three inches from the median line and faintly in the first space. In the second space the aneurism was very tender. On July 8, 1912, he walked about three miles.

Operation (July 20, 1912).—About 22½ feet of No. 29 "clasp" wire, shaped in evenly curved loops 6 to 7½ inches in diameter, were introduced. The current used was 100 ma., 50 ma., 40 ma., and 30 ma., each for fifteen minutes. Just before the operation the patient, when resting, had had but little pain, so that no marked immediate effect from the operation was noted. The second night following the operation the patient was conscious of a marked diminution in the pulsation and he began lying on his right side which previously he had been unable to do. After five weeks in bed he soon was climbing three flights of stairs (not by advice) without trouble, and on September 20 he easily lifted one end of a 150 pound weight.

The interesting feature of this case is the considerable amount of labor that he has been able to perform. Excessive exertion has frequently brought on temporary pain which has always gone away with stopping the physical effort. The attacks of exacerbation of coughing with considerable expectoration have usually come on following exposure to wet. There has never been pressure on the trachea causing any obstruction to the breathing.

That this patient has been able to put forth such exceeding physical effort would seem to indicate that the wiring operation and the arrest of the aortic disease by the medication had together strongly fortified the aneurism wall. The patient has frequently mentioned that the taking of coffee has seemed to give him pain. Also he has sometimes attributed the pain to gas in his stomach. Pain in his chest following the taking of food is relieved by belching gas. Figs. 2, 3, 4 and 5 show X-rays of this aneurism at different periods of time.

Antispecific treatment was withheld until September 30, 1912, when mixed treatment was begun and taken for six weeks out of every eight up to March 15, 1913. Between January 10 and February 16, 1913, he was given 3 doses of neosalvarsan 0.3, 0.45, 0.6 g., following which his activities became very much increased. He seemed to experience the most decided improvement, however, the middle of March on stopping the mixed treatment, when he observed that he felt stronger and that practically all pain left. Two weeks later on beginning mixed treatment again, pain returned, but on stopping this medicine it again went away. The writer has noticed an apparent intolerance for potassium iodide for a time after one of the salvarsan preparations has been given. Wassermann on February 16, 1913, had become negative and was still so on the following May 12.

The patient returned to work, taking up his former job on the drill press, the end of October, 1912, up to which time he had been having a little pain lasting a few minutes four or five times a day. He kept at this employment for a week, having pain most of the time while at work. For three or four weeks in November and December the effort of lifting gates at a railroad crossing by means of a crank, at first caused only a little pain, but with stiffening of the machinery he was obliged to relinquish the job. Two days after stopping this work the pain entirely left. Prior to receiving neosalvarsan he would have a little pain if he walked as much as half a mile in fifteen minutes. On February 6, 1913, eleven days after his second dose of neosalvarsan, he walked about eleven miles without a symptom. On the night of February 11, 1913, he cranked the railroad gates, which was pretty heavy work, having no pain until the following afternoon. Early in the following March he worked in a machine shop where he had to lift about 20 pounds about every quarter of an hour for nine hours a day. Thus employed, for two days he had no pain, but on the third and fourth days pain ensued and he had to stop. On May 3, 1913, the record states that he was not working, but was daily climbing six flights of stairs to his room and walking five or six miles and had no pain or cough. On May 14 he worked eight and a half hours, carrying refuse cans weighing

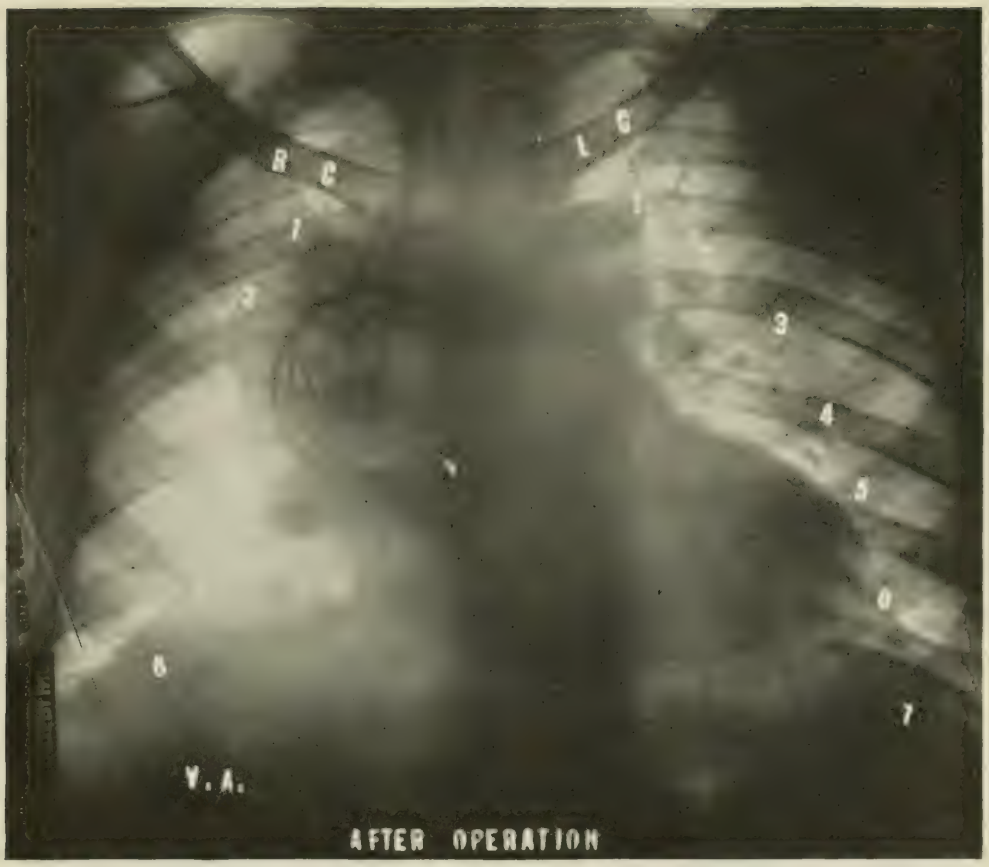

FIG. 1.—Patient V. A., after the wiring operation. (Taken by Dr. Byron C. Darling.)

FIG. 2.—Patient G. S. X-ray of July 12, 1912, before operation. Direct anteroposterior view. (Taken by Dr. Leon T. LeWald.)

FIG. 3.—Patient G. S., after the wiring operation. Exposure slightly oblique so that the shadow is thrown a little more to the left than it would have been in a direct anteroposterior view. (Taken by Dr. Byron C. Darling.)

FIG. 4.—Patient G. S., July 30, 1914. Direct anteroposterior view. Compared with Fig. 2, it shows about ½ an inch increase in transverse diameter of the aneurismal shadow since before the operation. (Taken by Dr. Leon T. LeWald.)

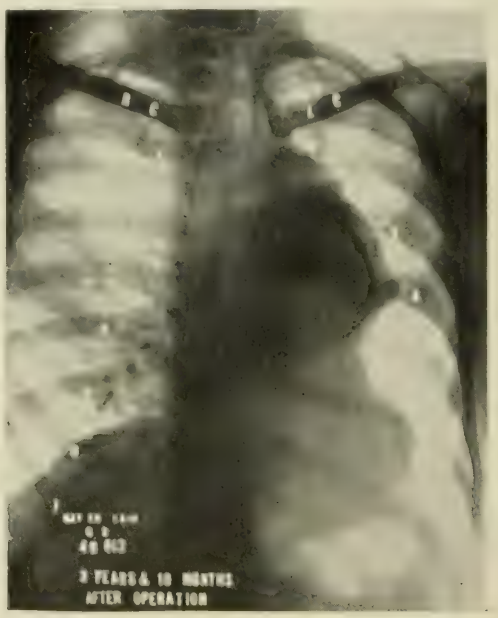

FIG. 5.—Patient G. S., May 28, 1916. Exposure slightly oblique, so that the aneurismal shadow is pitched a little too far to the left for a comparison of its size with that of the shadows in the direct anteroposterior views. Small area of bulging to the left. (Taken by Dr. Leon T. LeWald.)

FIG. 6.—Patient G. S., May 28, 1916. Stereoscopic X-ray of the wire, viewed from the side. Size for hand stereoscope (Taken by Dr. Leon T. LeWald.)

about 100 pounds a distance of about 100 feet and loading them on a truck, and throwing bags weighing about 70 to 100 pounds down a chute. He had no pain but experienced heavy throbbing. On June 13 he spat up about ten mouthfuls of bright red fluid blood. The hemorrhage subsided. In the summer of 1913 he had pain only on occasion from excessive effort. Thus in August he was employed where he used an 18-pound sledge hammer at intervals, and was obliged to lift about 100 pounds. He worked at this job five days and left because he had a little pain which lasted only about one day. A job at heavy filing ten hours a day caused a little pain while at work. September 2, he got a job in a machine shop running a big radial drill where he had to lift 30 to 50 pounds several times per day. He had had no pain after eight days of this work. With a view of reducing his physical effort, he was then sent, with the coöperation of Dr. Warren Coleman, to the Sharon Industrial Home for Cardiacs, but he soon went back again to work on a drill press, where this time, however, the work was lighter, he usually not having to lift more than five or six pounds.

In the fall of 1913 his Wassermann having become positive again, further antispecific treatment was administered. Between November 30, 1913, and March 29, 1914, he was given 14 intramuscular injections of mercury, and on January 18, 1914, neosalvarsan 0.45 g. From March 16 to August 10, 1914, excepting for three weeks, he was given potassium iodide grs. v to vii or mixed treatment t. i. d. For three weeks in September and October he returned to the potassium iodide but he finally complained of its giving him pain in the stomach so that it was stopped.

Between November 18, 1913, and February 7, 1914, he worked off and on doing the lighter work on the drill press, having but very little pain and that only while at work. He would go for intervals of several days at a time without any pain at all. There was no immediate improvement noticeable following the neosalvarsan on January 18, 1914. On January 24, 1914, he had no cough or expectoration. His cheeks were rosy and his general health excellent. On February 19 he got wet and caught cold and had cough with expectoration until the end of March, the cough continuing into May. From February 7 to August 15 of this year he did but little work. In June he worked seven days on a drill press, lifting weights up to 75 pounds without having any pain. Notes of July 18, 1914: Has had no pain in about six weeks, he last having had a little after a ten-mile walk. Has had no cough since early in May. Whenever he is out of work he walks from six to eight miles a day. His health is excellent. These notes were made at a time when he had been practically out of work for five months, though he had walked considerably, and after having taken potassium iodide pretty steadily for four

months, following a long course of mercury injections given during the winter and one dose of neosalvarsan in January. He got over his cough in May while he was taking potassium iodide. On August 15, 1914, he sailed for Liverpool as seaman on the "Saxonia" and later returned on the "Lusitania." On this trip he carried food cans weighing about 20 pounds, scrubbed forecastles, pulled on hoisting-ropes, and for about one hour handled trunks. During the latter job he had a very little pain, which subsided as soon as he stopped working, otherwise the pain he experienced on this trip was insignificant. On the "Lusitania" he got wet and, having to live in his damp clothes for two or three days, caught cold. He then had cough with thick expectoration in the mornings. His cough continued into November. Around December 5, 1914, he was usually not coughing. From October 5, 1914, to January 5, 1915, he worked on a drill press, which labor, though light, was for long hours. Through the fall up to the middle of December, 1914, he had practically no pain. Then he caught another very bad cold and pain in his chest returned, the pain generally lasting for short periods of time and recurring at intervals of one or more days. After he stopped working in January the pain soon left. While out of work he walked several miles a day. On returning to light work in an automobile shop he had some recurrence of pain.

In January, 1915, he took potassium iodide, grs. v t. i. d., on stopping which his cough got a good deal better. Between November 7, 1914, and January 9, 1915, he was given seven injections of mercury salicylate.

On February 27, 1915, he embarked again on the "Lusitania" as a seaman and returned to New York May 24, during which time he had only one attack of pain and that while working ashore, as a result of which he went to a hospital where he spent three weeks. On his return from abroad he had a cough. He then took some more mixed treatment. After his return he did no work for at least a month. An occasional pain he had during this time he attributed to taking coffee. Around June 23, 1915, he was coughing only a couple of times on getting up in the morning and three or four times during the day.

In August, 1915, his Wassermann being 12 units positive as rigorous a course of antispecific treatment as his work would permit was instituted. On March 16, 1916, his Wassermann was 5 units positive. Between August, 1915, and April 9, 1916, he was given fifteen injections of mercury salicylate, ¾ to 1 gr. each, and on March 16 he was given diarsenol 0.3 g. He also took potassium iodide grs. x t. i. d. most of the time from about the first of September, 1915, to January, 1916. The end of Sep-

tember, 1915, his cough had entirely stopped, but on October 1 he got his feet wet again and caught another cold. About the first of January, 1916, on stopping the potassium iodide, the cough which had been pretty bad became much easier. About the first of February, on resuming the potassium iodide the cough became bad again, so that he stopped this drug and again the cough lessened. Since then no more potassium iodide has been given. After the middle of February the patient got his feet wet on shipboard and took cold, and cough and expectoration again became pretty bad. He now had two or three severe coughing attacks to raise thick expectoration every night. Immediately following the diarsenol on March 16, 1916, the expectoration became thin and much reduced in amount and the cough became much less severe, the night attacks ceasing. Around April 9 his cough was less and he was having only a little expectoration mornings. However, on April 17, with a sudden change of temperature in the work-room, he again caught cold and began again to cough a good deal and to expectorate thick phlegm. While his cough was pretty bad up to the middle of May, disturbing him at night, it then improved so that he coughed only on awaking in the mornings to raise expectoration and very little in the daytime. His own notes state that for two weeks after receiving the diarsenol he had a slight pain at night lasting one-half to one hour. In the month following the taking of this drug he lost six pounds in weight, yet in this time his cough and expectoration had greatly decreased.

In August and September and again in November and December, 1915, he worked on a drill press. On January 24, 1916, he made a trip to Liverpool on a cattle-ship where he carried hay and water to feed the cattle. About the first of March he obtained employment as a marine machinist in which capacity he had to lift up to 20 to 30 pounds. On March 10 he carried about 50 pounds of coal up three flights of stairs without stopping, which made him a little short of wind. March 14 he walked a mile in seventeen minutes. On March 27 he walked about five miles, carrying his tools for two of the miles, and during the last mile he had a little pain over the aneurism. During a part of April, 1916, he worked on a light drill press. From May 1 to May 27, notwithstanding his cough, he put forth great effort. He worked overhauling ship pumps, lifting generally weights of from 10 to 20 pounds, but four or five times a week he would lift a weight of 80 to 100 pounds. On three of these days he did 14 hours of actual work and on nine days 12 hours of actual work. During the last two weeks on this job his cough and expectoration became greatly improved. During the whole time on this job,

he had only very occasionally a slight touch of pain, lasting about five minutes. On June 3, the patient reported that he was obliged to eat four meals a day to satisfy his appetite. Examination of sputum for tubercle bacilli on May 30 was negative. No signs of apical lesions.

During the past summer (1916) the patient has practically done no work. He took red iodide of mercury pills for about eight weeks. August 24, 1916, Wassermann negative. Toward the end of September he shipped as a deckhand on the "St. Paul." On this trip he had no pain while at work. He was last seen on November 3. Since early summer he has had some cough which has been for the most part dry. During this time except in the hottest season, he has generally walked several miles a day. Often after walking 2 or 3 miles he has had a little touch of pain, which has gone away with resting and to which he has paid little attention. He claims that the eating of fried eggs gives him slight pain. He is looking and feeling very well and has a big appetite.

LATE NOTE.—The patient dropped dead on the street November 16, 1916. Autopsy showed intrathoracic rupture of the aneurism. The aneurism specimen has not yet received a thorough examination.

The writer is indebted to Dr. George B. Wallace for his coöperation in the care of this case.

The Antispecific Treatment of Thoracic Aneurism.—The writer wishes to emphasize the importance of treating the syphilis in thoracic aneurism, as a means of controverting the symptoms and prolonging life. The antispecific treatment must be administered according to rule [1] to obtain good results. The writer's rule is that potassium iodide and mercury must first be administered for four or five or six months before one of the salvarsan preparations or diarsenol is given. Lesser,[2] of Berlin, states that in treating tertiary syphilis potassium iodide and mercury should always precede the administration of salvarsan. The mercury should preferably be administered by intramuscular injection. The preliminary treatment with the older remedies, combined with rest, has, in not too advanced cases, for a time anyway, attained much for the relief of the symptoms. It is, however, following a long preliminary treatment with potassium iodide and mercury, after one of the salvarsan preparations or diarsenol has been given, that a further betterment is very promptly effected, which is more enduring than that

[1] Lusk: Discussion on Thoracic Aneurism. N. Y. Medical Record, March 27, 1915, p. 540.

[2] Lesser: Berl. kl. Wochenschrift, March 16, 1914, p. 494.

which can be obtained with potassium iodide and mercury alone. Any cough then diminishes, and pain, if present, is lessened or vanishes and the patient becomes possessed of a sense of well-being not before experienced. In two cases of thoracic aneurism, to whom small doses of salvarsan were given as their chief treatment, at intervals over a period of several months, without the preliminary use of potassium iodide and mercury, the symptoms became aggravated and the patients died. It would seem probable that it is the preliminary control of the gummatous infiltration of the aortic wall by the potassium iodide and mercury which gives particular efficacy to the spirochætacidal action of the subsequently given salvarsan or diarsenol. In the observation of the writer, in cases of thoracic aneurism pretty generally, it has seemed that, for some time after salvarsan or diarsenol has been administered, if potassium iodide were given, pain would result or cough and expectoration, if present, would be increased. He therefore always stops potassium iodide before giving salvarsan or diarsenol and withholds it for a considerable time thereafter. To one case of thoracic aneurism with a cough, who had had no salvarsan for as long an interval as a year, small doses of iodulose were administered, the giving of which was attended with a marked exacerbation of the cough which became very distressing at night. However, on stopping the iodulose, the aggravation of the cough at once disappeared.

Mercury should be omitted for five days before and for five days after the administration of salvarsan or diarsenol for fear of kidney complications. After one of the latter drugs has been given, mercury seems to take on a renewed efficiency. The writer repeats the salvarsan or diarsenol about once a month, being guided as to the number of injections given by the Wassermann reaction, and in between doses he gives mercury again under the precautions above stated. It is these injections of mercury between the injections of salvarsan or diarsenol that seem to give added recuperation to the patient. The writer had until the past winter used neosalvarsan 0.45 g. since Alwens [3] had shown experimentally that neosalvarsan given in proportionately large doses to rabbits was little liable to produce nephritis, while old salvarsan in lesser dosage was very liable to do so. He now uses diarsenol 0.3 g. with which the results in the few cases treated have been entirely satisfactory.

The use of the diarsenol, which is supposably the equivalent of old salvarsan, has seemed to be more generally effectual than was the neo-

[3] Alwens: Archiv. f. Experiment. Pathol. u. Pharmak., Bd. 72.

salvarsan. When, after the primary series of salvarsan or diarsenol has been given to these cases, it becomes necessary to give a subsequent course of antispecific treatment, if potassium iodide cannot be taken, a course of mercury alone should precede the giving of the salvarsan or diarsenol.

The writer administers the potassium iodide in doses of not over 10 grains t. i. d. He uses the salicylate of mercury for intramuscular injection in doses of not more than one grain, repeating the same generally at five-day intervals. He would call attention to the facts that abdominal cramps and diarrhœa following an injection of mercury are indications for reducing the dose, and that fetor of the breath or swelling of the glands of the neck with perhaps swelling of the tonsil, too, are just as much indications for interrupting the mercury as is soreness of the gums and teeth. With the giving of the diarsenol or salvarsan, the condition of the urine should be watched with particular care.

Without the antispecific treatment in cases of thoracic aneurism, the relief of symptoms coming on as a result of the wiring operation lasts only for a short time, because the disease in the arterial wall remains unchecked and the aneurism will consequently resume its growth.

In trying to estimate the effect of treatment on the growth of the aneurism in the case of G. S. herein reported, from X-ray plates, it must be noted that of the four illustrations of this case grouped together, Figs. 3 and 5 do not furnish outlines for accurate comparison with the others, since they were taken a little obliquely and therefore throw the shadow a little farther to the patient's left than a direct front to back picture would have. Figs. 2 and 4, however, being both direct anteroposterior views give a fair estimate of the change which had taken place two years after the operation, which consisted in a broadening of the shadow about half an inch as measured in the original plates. The X-ray of May 28, 1916 (Fig. 5), shows a small area of bulging to the left, not before observed.

The patient G. S. has been given considerable potassium iodide. That which he took soon after the operation and before getting his first neosalvarsan was undoubtedly highly beneficial and very necessary Continuing his mixed treatment during the time he was getting his first three doses of neosalvarsan and for a month thereafter, he seemed to get his greatest benefit following the neosalvarsan, after the mixed treatment had been stopped. This is in keeping with the theory of incompatibility between potassium iodide and the salvarsan preparations.

Symmers and Wallace : The Etiology of Syphilitic Aortitis.
Jour. A. M. A., Feb. 5, 1916, lxvi, pp. 397-400.

Loncope : Syphilitic Aortitis : Its Diagnosis and Treatment.
Archives Int. Med., Jan., 1913, vol. ii, pp. 15-51.

In the fall of 1913 there was referred to the writer by Dr. C. D. Van Wagenen a case of aneurism of the aortic arch,[4] whose X-ray picture at that time compared with one taken at the same focus and in the same position 16 months earlier, showed a lateral shrinkage in the aneurismal shadow of from 1 to 1¼ inches to have taken place. Also it was found that the physical signs of aneurism of the aortic arch, which has been present in this patient, no longer existed. All the treatment this patient had had was rest, small doses of potassium iodide given very irregularly and a few injections of mercury. Deducing from this result that potassium iodide might be able to cause diminution in size of an aneurism, beginning on March 16, 1914, the patient G. S. was given small doses of potassium iodide over a period of 5 months. This dosage was instituted just following a long course of mercurial injections and one dose of neosalvarsan given the preceding January. While the patient was taking this potassium iodide he practically was doing no work, though he walked considerably, and after the fourth month of this medication his health was excellent and he had no pain or cough. It was just about this time that the X-ray picture shown in Fig. 4 was taken. Besides this course of potassium iodide, he had had another one of particular length previously from September 30, 1912, to March 15, 1913, and received still another subsequently from about September 1, 1915, to about January 1, 1916. Following the course of potassium iodide given in the spring and summer of 1914, whenever resort was had again to potassium iodide he either had, or developed, a cough which would seem to be aggravated by this drug, since on stopping the latter the cough would always get better. Finally (February, 1916) further attempt to give potassium iodide was given up on account of its baneful effect on the cough. In some cases of thoracic aneurism, cough seems to be increased as a result of the long continued use of potassium iodide irrespective of the taking of salvarsan or diarsenol, the appearance of which manifestation probably signifies that the limit of tolerance to this drug has been reached. The X-rays show no evidence of gross shrinkage in the size of this aneurism as a result of the treatment.

In one other case, a mesially situated aneurism of the arch, in which careful comparisons were made of X-ray plates before and after a six-month interval in which the patient had rested and had received 29 injections of Hg salicylate from ½ to 1 grain, and small doses of potassium iodide for a large part of the time, the shadow was found to have remained the same size. This patient up

[4] Lusk: Annals of Surgery, lx, 1914, p. 535.

to that time had had no diarsenol or salvarsan. Thus it can be argued that potassium iodide in small doses will not extensively diminish the size of an aneurism.

When one thinks about it, it is hardly to be expected that a diseased aorta considerably converted into adventitious tissue, which has dilated, can possibly become very much reduced in size, even under circumstances most favorable for the healing of the gummatous infiltration and the destruction of the spirochætes. A slight shrinkage however as a result of the control of the disease and the reduction of spirochætal activity, could explain the relief of symptoms following treatment. Yet the enlargement of the aneurism in the case of G. S. within the first two years following wiring (Fig. 4) would seem to indicate that a certain amount of accommodation of the surrounding tissues to the pressure of the tumor may take place. Recent descriptions of the pathological anatomy of syphilitic aortitis have been published by Symmers and Wallace and by Longcope.

The writer is inclined to believe that in cases of mesially situated aneurism of the aortic arch, who suffer from acute dyspnœic attacks associated with sudden great pressure on the trachea, and who become greatly alleviated or relieved shortly following the administration of morphine and atropine, the existence of a mediastinal œdema can be offered as a rational explanation of the sudden acute symptoms. There is usually in these cases an area of superficial veins on the upper part of the front of the chest which, like a tell-tale, remain congested while the symptoms are more or less acute. In a case of this sort recently treated medically, the paroxysms of acute dyspnœa were promptly relieved by a hypodermic of 10 minims of adrenalin, which result would favor the theory of a mediastinal œdema being the cause of the acute pressure on the trachea. Relief, which was marked and more lasting than that obtained by any other means, was given to this patient by an injection of neosalvarsan 0.45 g., which, however, came after considerable antispecific treatment had already been administered. In the case referred by Dr. Van Wagenen, the subsidence of a mediastinal œdema might explain the very large reduction in size of the X-ray shadow corresponding to the thoracic aorta.

Dr. G. Reese Satterlee [5] has reported a case of thoracic aneurism to whom he began to give antispecific treatment in May, 1911, and who, Dr. Satterlee advises me by personal communication, is to-day (June, 1916) living in comfort and doing light work. The patient was early

[5] G. R. Satterlee: N. Y. Medical Journal, Jan. 13, 1912.

given two small doses of salvarsan, besides which to date he has had 125 intramuscular injections of mercury, and with the intermission of a year, he has been given 90 grains of potassium iodide a day continuously since treatment was begun. Dr. Satterlee, in his report, described a penumbra seen with the fluoroscope, lying to the left of the shadow of the arch, which he interpreted as being a probable "syphilitic deposit" skirting the aneurism. He says that a year ago the penumbra was still present, though of a lesser density than in the beginning.

The Operative Treatment of Thoracic Aneurism.—The antispecific treatment cannot be relied upon to cause strengthening of an aneurismal dilatation much weakened by stretching. It is to offset or to forestall the growth of a weakened aneurismal area of this sort that the Moore-Corradi operation of wiring with electrolysis is indicated, as a result of which, if a clot can be thrown down on the inner surface of the dilated area, a means of repairing the latter is thereby furnished which will rapidly bring relief to the symptoms, and will probably cause shrinkage of the local tumor. Aneurisms not compressing the trachea, which are very large or prominent and therefore liable to rupture, are suitable ones for early wiring. The median aneurisms which press on the trachea with sufficient force to compromise the breathing are still a study. Unless too far advanced they seem to do well with the antispecific treatment alone. The writer has wired two of these cases. One of them, treated afterward with the antispecific remedies, lived for about 3½ years, and the autopsy showed that the wiring had accomplished nothing. The other case had a sacculation projecting above the manubrium, in which a clot formed as a result of the operation and the patient died soon after the operation from tracheal obstruction.

A principle in the technic of the wiring operation to be emphasized, is that of contact of as much as possible of the introduced wire with the inner surface of the aneurismal wall, since clot produced by the electrolysis in the course of the wire, in order to find permanent lodgment where it can undergo organization, must be deposited on vitalized tissue to which it can adhere. A coating of fibrin which is laid down by the electric current on that portion of the wire which projects free into the swiftly-moving blood stream soon becomes loosened from its attachment, leaving the wire bare. The localities within an aneurism where the blood is most likely to become clotted by an electrified wire, are where the aneurism is recessed, at which situations close to the aneurism wall the aortic blood current must be slowed to a greater extent than anywhere else. If no recess should exist, as in cases where the dila-

tation of the aorta might be a purely fusiform one, then the efficacy of the wiring operation would be in question, from the probable inability of a suitable clot to form in the presence of very rapidly-moving blood. In the case of G. S. the position of the wire shows that the first portion of the aorta was simply dilated to the left into a recess, the recess forming a part of the main conduit for the blood, thus demonstrating that the aneurism need not necessarily be a purely sacculated one for the wiring operation to be of avail. A recess would naturally correspond to a site of weakening of the aneurism wall, since it is at such situations that the most stretching has taken place. Consequently the recesses are the sites needing to be strengthened. Since the prominence of the aneurismal tumor, where the puncture with the insulated gold needle is made, generally indicates the site of a recess, the wire must be manipulated by shaping in such a way that some of the loops as they are introduced will come back so as to touch the area of sac wall adjacent to where the needle point has entered the cavity. In order to manipulate the wire from without in a way to control in a measure its arrangement within the aneurism, a resilient wire is used, the "clasp" gold wire[6] No. 29, which being properly shaped before operation, will after passing through the needle regain its shape within the aneurismal cavity. To favor the coming back of the wire during its introduction so as to make contact with the aneurism wall around the site of entrance of the needle, it was found by tests in a glass flask, that if a loop of the wire, shaped so as to have a smaller diameter than that of the flask, were interposed between about every two larger loops having a diameter greater than that of the flask, than each smaller one, when first introduced, posing within the flask under little or no restraint other than that of the wire with which it was continuous, would tend to assume a position about in a plane passing through the long axis of the shaft of the needle. As the larger loops of the wire now followed each smaller one, the latter would become expanded as far as the confines of the cavity would permit, and, lying in the plane above mentioned, as it expanded it had to retrieve to alongside of the needle point. This interposition of smaller between larger loops of the wire has seemed to establish a varying direction for the loops, resulting in a more or less general peripheral arrangement of the wire than when the wire is shaped in loops all of a diameter which is larger than that of the aneurismal cavity.

In order to bring as much wire as possible into contact with the aneurism wall, the wire, first straightened, should be shaped in undulat-

[6] Lusk: A Thoracic Aneurism Treated with Gold Wire and Galvanism. ANNALS OF SURGERY, June, 1912, pp. 789–803.

ing curves, and then this undulated piece of wire again curved so as to form loops. The peripherally lying crests of these undulations have a better chance of making contact with the aneurism wall than a wire of one even curve would have, both by their being better able to fit the irregularities of the cavity and as well by being able to dip down through the interlacement of the loops of wire already laid down. In the last case wired, the crests of the undulations were somewhat flattened with a view of securing contact of a greater length of wire than could be gotten with a crescentic shape. The undulated wire allows more give and therefore takes a peripheral arrangement under less tension than does a wire curved evenly in large loops. Also the undulations as they interdigitate make a deeper mesh of wire to possibly aid in the entanglement of blood clot at the wall of the cavity. The entering extremity of the wire is always shaped in an expanding spiral so that it will come back toward the needle point as it enters the aneurism and lodge free in the central portion of the cavity. The portion of wire which is last introduced and which is to be left in the needle track after the needle has been withdrawn, should be straight, and the portion of the wire introduced just in advance of the straight piece should be shaped in a couple of very small loops which will lie free within the cavity of the aneurism, thus relieving all tension from within on the terminal portion of the wire which is left buried in the chest wall. The first time the writer used the undulated wire on a case of aneurism, the needle was found to be of too small a bore to allow the free passage of the undulated wire, which feeds in under much greater resistance than does the evenly-curved wire, so that finally with the clotting of the blood in the needle the wire jammed. After withdrawing the needle the piece of the wire left in the needle track tended to regain its undulated form, thus exerting pressure on the adjacent tissues, which caused necrosis along the track of the wire, and this in turn was followed by rupture through the skin and death of the patient from hemorrhage. The larger loops are generally shaped so as to have a diameter of about 5 inches, and the smaller loops, a diameter of about 2½ to 3 inches. Four cases of thoracic aneurism have been wired, using the undulated wire with the smaller loops interposed between the larger. Of one of these patients whose aneurism formed a small prominent tumor on the front of the chest, and in whom a No. 30 wire was used, it was reported three and a half months after the operation, that the tumor had receded so that the chest wall was flat. Another of these patients, who died with symptoms of cerebral embolus, had a broad clot adherent to the wall of the aneurism underlying the area through which the puncture

with the needle was made, and in the clot considerable wire was embedded. In the third case hardening of the aneurism around the site of puncture ensued. The fourth case, who had a pulsating tumor which projected quite high from in front of the sternum, died from rupture four and a half months after the operation. At autopsy it was found that there was an extrathoracic expansion of the aneurism which communicated with the intrathoracic portion by a perforation through the sternum about 1¼ inches in diameter, through which bony opening the wire had passed to become deposited within the intrathoracic portion, in the recesses of which organized deposit was found entangled in the peripherally located wire. Thus the extrathoracic portion of the aneurism got no protective clot formation within it, yet the external tumor primarily following the operation receded very much in size. In the two latter cases the current used was 100 ma. for 30 minutes.

The autopsy in the last case just cited, has shown that the current of 100 ma. electrifying the introduced wire for thirty minutes, caused a good deposit to be laid down in those localities in which it was possible for deposit to form, which had undergone organization. The writer also is inclined to believe from his experimental work, that, with the use of a current of 100 ma. for thirty minutes, less extraneous fibrin will be deposited during the electrical séance on the portion of wire in relation with the very rapidly flowing blood, than there would be with the sequence of 100 ma., 50 ma., 40 ma. and 30 ma. each for fifteen minutes, as heretofore used. The writer advocates making the wire grease-free, since in dogs a grease-free wire produces the more reliable clotting. The wire when first straightened out before being shaped, should have the grease from the shop removed from it by stripping it with gauze wet with alcohol. When the wire has been shaped and is coiled ready for use it should then be boiled in a 10 per cent. to 15 per cent. washing soda solution for further removal of grease, then rinsed in plain water to remove the soda, and finally boiled once or twice more in distilled water.

The writer has wired the aortas of 239 dogs in the surgical laboratory of the New York University and Bellevue Hospital Medical College, to which institution as well as to Dr. Richard M. Pearce, former Professor of Pathology, Dr. John W. Draper, Associate in Experimental Surgery, and Prof. Douglas Symmers personally, he is indebted for many courtesies in the course of this work.

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ANEURISM TREATED WITH THE ANTISPECIFIC REMEDIES ALONE

DR. WILLIAM C. LUSK said that in reporting the two cases of wired thoracic aneurism which he showed before this Society on May 10, 1916 (ANNALS OF SURGERY, lxiv, 1916, p. 680), he had dwelt upon the importance of giving antispecific treatment to these cases as a measure which, if the disease were not too advanced, could bring relief to their symptoms, could increase their activities and could prolong life. However, he had insisted that to get good results in these cases, the antispecific remedies must be administered according to a definite plan, which had proved satisfactory in his experience and which he believed was applicable to all cases of tertiary syphilis.

The plan was as follows: To give potassium iodide and mercury for from four to six months before any salvarsan was given, and to continue the mercury between the doses of salvarsan. Thus it was considered that the gummatous infiltration in the aorta was first controlled by the earlier treatment, which preliminary preparation seemed to give an especial impetus to the action of the salvarsan, since, when the latter was then given, the improvement in the symptoms would be marked—cough and tracheal obstruction would be lessened, pain could be expected to disappear, and the patient would become possessed of a sense of well-being and would acquire a capacity for greater physical effort. Potassium iodide was given in doses of ten grains three times a day, and mercury generally by injections of the salicylate not to exceed one grain every five days, interrupting these drugs as occasion required. Before giving salvarsan the potassium iodide must be stopped, since, when potassium iodide had been given following salvarsan, it had seemed sometimes to have caused pain, and, even for months afterward, to have been particularly prone to excite cough. Potassium iodide appeared to supply a real want in the early treatment of thoracic aneurism, but when it had once been given for a long period of time prior to the salvarsan, as here recommended, any subsequent usefulness of this drug had seemed problematical. It had seemed very important that mercury be given between the doses of salvarsan, to the beneficial effects of which thus administered the patients themselves would bear testimony. The salvarsan, or diarsenol, 0.3 gram was given about once a month, being guided as to the number of injections partly by the Wassermann reaction and partly by the effect of the treatment on the control of the symptoms and on the activity of the patient. When, with a lapse in treatment of a thoracic aneurism, symptoms recurred for which further treatment became necessary, it had

seemed best to administer mercury alone for a while before giving the next dose of salvarsan. Mercury should not be given within five days before, or five days after, salvarsan. The urine should be watched.

More lasting benefit in the treatment of tertiary syphilis had seemed to come with the use of old salvarsan or diarsenol, consequent upon a preliminary treatment with potassium iodide and mercury, than with neosalvarsan (*vide* cases 1 and 3).

Cases of thoracic aneurism touching the chest wall, which were suitable for treatment with the antispecific remedies alone without wiring, were those without much recess formation in their contour, indicating an absence of great stretching with thinning of the aneurism wall in any particular locality.

Case I.—V. K., age thirty-seven, laundress. Mesial aneurism of aortic arch, referred through the courtesy of the late Dr. A. A. Smith, at Bellevue Hospital. Onset in January, 1914, with pain, which became severe, but the following June disappeared, leaving a soreness. In March, 1914, she lost her voice, and the following August she had her first choking attack in which her throat was full of " rattles," evidently a bronchorrhœa, which was relieved by a hypodermic injection. She had six of these attacks before entering Bellevue on September 29, 1914, where she was put to bed and given potassium iodide in moderate doses and injections of mercury salicylate. In December, two weeks after an interruption of her potassium iodide, she developed a very bad attack of obstructed breathing with bronchorrhœa, but on giving potassium iodide again in ten-grain doses, the acute symptoms left. After her preliminary treatment with potassium iodide and mercury she was given in the spring of 1915 four injections of neosalvarsan 0.45 with mercury salicylate in between. She left Bellevue July 4, 1915. Wassermann, September 30, 1914, six units; January 30, 1915, fifteen units; the following June 9, two units, and August 18, negative. In August, 1915, she was able to walk three blocks before she would have an attack of hard breathing, which latter would disappear on resting. She had regained her voice. During that summer she gained twenty pounds, but her health continued precarious, and in the fall she began to have dyspnœic attacks again, with pain and throbbing, irrespective of exertion. Potassium iodide in five-grain doses now increased her cough and expectoration, and after a short trial was discontinued. She was given a few injections of mercury. On November 22, 1915, she had a severe attack of tracheal obstruction, and she re-entered Bellevue Hospital. Wassermann, fourteen units. Potassium iodide, tried again, once more increased cough and expectoration and had to be stopped. She was given injections of mercury salicylate, under which she improved so that she was able to walk about the ward without distress in breathing. On January 18, 1916, she caught cold, which was followed by a series of attacks of labored breathing from pressure on the trachea, accompanying which the superficial veins on the front of the chest would become distended. It was found that these attacks of shortness of breath would become re-

lieved in a few minutes accompanied by a diminution of expectoration and cough, following a hypodermic injection of ten minims of adrenalin. The blood-pressure was low. Between January 22 and 29 it varied from 105 to 118. A few doses of 1/150 grain atropin were also given and the patient improved somewhat. Marked improvement, however, followed the giving of a dose of neosalvarsan 0.45 on January 29. Just before receiving this medication the only position in which the patient could sleep was on her back with her head turned to the left side. Any attempt to lie on either side would produce hard breathing and choking. On January 30, the day following the giving of the neosalvarsan, the patient passed a very comfortable day and slept the greater part of the ensuing night. On January 31 the patient coughed but little and began to rest some on her sides, and by February 5 she was able to rest with comfort on either side.

The patient continued to improve. On March 17, 1916, she was given diarsenol 0.3, and on May 4 she was given of the same drug, about 0.24. She left Bellevue the middle of May, at which time she could walk and stand around the ward a good deal of the time with perfect comfort. She then had no shortness of breath unless she hurried. She could sleep in any position. She coughed very little. During all of this time that she was in the hospital she received mercury either in the form of the salicylate or by inunctions. She has a peculiar reflex, in that whenever she gets an injection of mercury she immediately becomes nauseated and remains so for from twenty-four to thirty-six hours.

Since the patient had the diarsenol in the spring of 1916 up to the present time she has had no serious relapse. Once last November she caught a cold which was accompanied by a little shortness of breath, but this soon disappeared. On Labor Day she walked twenty blocks without any ill effects. She has been employed during the winter as secretary, at which occupation she works from two to six hours a day. She walks generally four long blocks a day and climbs two flights of stairs to her room. She has had no chronic cough since last spring. Two days ago, wishing to indulge herself in a long walk, she covered in different stages about two and one-half miles without any trouble. She occasionally sings in the choir. She has taken some mercuric potassium iodide pills, one-sixth of a grain during the fall and winter. Wassermann, taken on November 14, 1916, was five units, cholesterin antigen. An X-ray taken February 26, 1917, compared with one taken May 8, 1916, shows that the transverse measurement of the aneurismal shadow has not changed.

Observations.—After this patient had been given neosalvarsan, whenever resort was made to potassium iodide, the latter always aggravated her cough, so that finally it was stopped, and afterward she made her final recovery with mercury in combination with one injection of neosalvarsan and two of diarsenol. While the patient made some temporary improvement following the four injections of neosalvarsan given in the spring of 1915, the beneficial effects of this drug

were not lasting, her health continued to be precarious, and before long she suffered a serious relapse. Since she has had the two doses of diarsenol last spring she has not had any serious relapse (now nine months), and she has had much more activity and comfort than she had before and has been able to enjoy life. It does not seem possible that the patient would have reacted from her condition of very acute tracheal obstruction in January, 1916, without the magical influence of the neosalvarsan, coming as it did in sequence with her prior antispecific medication.

In explanation of the sudden attacks of tracheal compression which occur in these cases with relief following a hypodermic of morphine and atropin or of adrenalin, the writer has stated elsewhere [1] his belief that they are due to a mediastinal œdema.

Case II.—H. W., age forty-six, druggist. Even enlargement of aortic arch. Onset with cough in December, 1914, followed by pain on exertion; slightly harsh breathing characteristic of a mild tracheal obstruction, and slight huskiness of the voice. There has never been any pulsation which could be felt transmitted through the chest wall. Beginning July 2, 1915, up to February 15, 1916, he was given five injections of salicylate of mercury of one grain each, four injections of three-quarters of a grain each and twenty-nine injections of one-half a grain each. For five months prior to December, 1915, he took potassium iodide in ten-grain doses with an occasional short interruption. In December, 1915, and January following, resort was again had to potassium iodide in five-grain doses on two occasions, but both times the cough became so aggravated that this drug had to be stopped. This was before any salvarsan had been given. It has seemed that when potassium iodide has been given over too long a period of time, even though salvarsan has not been taken, cough will result, as if to express that the limit of tolerance to this drug had been reached. On February 25, 1916, the patient was given neosalvarsan 0.45, and since that time he has been given diarsenol 0.3 four times, 0.2 once and 0.25 once, with thirty-three injections of salicylate of mercury one-half a grain each and mercurial inunctions for six weeks during the early part of the summer. On August 29, 1916, his Wassermann was fifteen units positive cholesterin antigen, and + + + alcohol antigen. On December 20, 1916, his Wassermann was 10 units positive with cholesterin antigen and negative with the alcohol antigen, this reduction in the strength of the Wassermann reaction having followed the giving of 3 injections of diarsenol 0.3 at intervals of a month, with injections of mercury salicylate once in five days between.

This patient has never suffered very acutely. His activities were limited for a long time by the occurrence of pain and shortness of breath on exertion. He consequently was inclined, while thus affected, to stay in his room. The cough has been the thing that has been prominent in his case and that has not generally been very distressing. It has

[1] Annals of Surgery, lxiv, 1916, p. 691.

been for the most part dry and evidently of a reflex character since it has been influenced by the position of the body. Up to early in January, 1917, if he would lie on his back or his right side he would cough, but he could lie on his left side without coughing. Latterly he has been able to lie in any position in bed without coughing. Up to the time of receiving his neosalvarsan on February 25, 1915, the patient had improved to a certain extent but his activities were very limited. The huskiness of his voice had disappeared. With the subsequent treatment with neosalvarsan, diarsenol and mercury the patient has gradually gained in strength and activity, and his symptoms have almost entirely disappeared. The patient has walked about three miles comfortably on each of the past three Sundays. Since stopping his antispecific treatment on January 8, 1917, he has since improved a good deal. At the present time he coughs but little and that only in the morning on rising and when he moves about. His breathing is a little hard only when he walks uphill. He is working again about three hours a day. Following the neosalvarsan and each injection of the diarsenol the improvement of the patient was quite noticeable and the patient always claimed that after each injection of mercury given in between times he likewise experienced a certain benefit. It was following his last injection of diarsenol on December 20, 1916, that he claimed to have been partially relieved of a feeling of pressure in the head and neck which the previous injections of this drug had not done, and that he breathed a great deal easier. X-ray pictures of this patient taken at the beginning of treatment, and before and since neosalvarsan and diarsenol have been given, show that the size of the aneurismal shadow has remained the same.

Case III.—B. F., aged 43, aneurism of left dorsolumbar region. Referred by Dr. S. Bradbury. Pulsation distinct though not forcible over region of eleventh and twelfth ribs about 2 inches from the vertebral spinous processes. Pain in the left side has been the prominent symptom. The patient sought hospital relief in December, 1913. In the hands of others, within the first six months, he states that he was given six injections of neosalvarsan and a great deal of potassium iodide. At the end of this treatment he stated that he had not been relieved of his pain at all. Thus from the writer's standpoint the treatment of this case was begun quite contrary to what might be expected to produce a satisfactory result. In the summer of 1914 he came into the writer's hands. He was suffering pain which prevented him from standing or sitting erect. He was given mixed treatment for about ten weeks with some relief for a while, but with later intensification of the pain. Then between October 21, 1914, and February 3, 1915, he was given 6 injections of neosalvarsan 0.45 and 16 injections of mercury salicylate. After each injection of neosalvarsan there would be some relief to the pain with more or less return of it soon after. In March and the first half of April, 1915, he was entirely free from pain but afterward the pain began to return. At this time he had not been working and had done little walking. He then went

into other hands again and was given considerable potassium iodide which did not help his pain any. The middle of August, 1915, he was again seen by the writer. With slight exertion he would have pain in his left groin and inner side of left thigh. Wassermann negative. He soon disappeared again and turned up August, 1916. For nine months previous to his return he had taken 5 drops of potassium iodide three times a day. Though there had been some variation in the amount of pain, he had had very little relief throughout the year.

What seemed finally to have given this patient more lasting relief from his pain under conditions of limited activity than had any of his former medication, was an injection of diarsenol 0.3 given on September 25, 1916, which was preceded by, and followed by, 5 injections of mercury salicylate grain I. The immediate improvement following the diarsenol injection was much more marked than had that ever been following an injection of neosalvarsan. The patient then left town and was not seen again until February 21, 1917, when he reported that since the end of October, as long as he had been inactive, he had not noticed the pain, which had been inconsequential. He could walk one or two blocks slowly without exciting pain. He could stand perfectly straight. He could sleep in any position. Pulsation was now difficult to detect. This experience would argue in favor of a preference for diarsenol to neosalvarsan. It is of interest that the Wassermann on September 18, 1916, was only 1 unit positive with cholesterin antigen, yet the symptoms, at that time uncontrolled, became greatly relieved following the giving of the diarsenol in conjunction with mercury.

Just after rendering the above favorable account of himself, while returning home in a trolley car, for no assignable reason, the patient had an attack of pain as formerly, which disappeared after a considerable rest, since which time the pain has recurred with only slight exertion such as walking around his room, and he can now lie only on his right side with comfort. The pain is however not so great as it used to be. It now passes around both sides of his body. There is no evidence of physical change in the aneurism.

Case IV.—W. H., age 58, laborer, referred by Dr. E. M. Raynor. Admitted to Bellevue Hospital October 19, 1916. Mesial thoracic aneurism of arch extending upward laterally to beneath the right clavicle and projecting prominently above the sternum, besides bulging to the left. In February, 1916, a lump began to grow in the neck and hoarseness developed. He had been short of breath on doing hard work and walking upstairs for about a year. If he lay in bed on his left side he would cough and have pain. When up, pain was excited only by working. Not much expectoration. Taking it easy he could walk about a mile without trouble. Some dysphagia. Would cough considerably when drinking water. Wassermann 15 units cholesterin antigen and ++++ alcohol antigen.

Treatment.—Since the patient has been in Bellevue Hospital he has had 9 injections of mercury salicylate of 1 grain each and 11 injections of ¾ grain each. He was at first given potassium iodide

in 10-grain doses for about ten weeks and a comparison of the X-rays taken before and after showed no perceptible change in the size of the tumor. Then wishing to determine whether potassium iodide given in increasing doses might not diminish the size of this aneurism, on January 9, 1917, this medication was started, and, increasing the dose 3 grains each day, the potassium iodide was run up to as high as 82 grains three times a day. When this latter medication was started the patient was recovering from an acute cold so that he was then coughing more than usual. The cough continued during the time of taking the intensive doses of potassium iodide with greater severity than ever before, and finally it became so bad, keeping the patient awake, and the nose ran so profusely, that this drug was stopped, following which the cough soon entirely subsided excepting when he drank water. An X-ray taken about three weeks after stopping this heavy dosage with potassium iodide showed no evident change in the size of the aneurismal shadow. At the present time swallowing is easier; he does not cough so much when he drinks, and the voice is much stronger, the latter improvement having taken place particularly since about the middle of January. He walks around the ward with a good firm tread, but gets short of breath if he hurries too much.

Observations.—This patient was presented at the end of his iodide and mercury treatment to emphasize the fact that this preliminary treatment with the older remedies should precede the giving of old salvarsan or diarsenol. Also to demonstrate the results of this preliminary treatment, *viz.*: No apparent change in the size of the aneurism, indicating that at least growth had not taken place, besides considerable improvement in general health, yet without restoration of much activity and vim, which latter would now be expected to supervene in this case with the giving of old salvarsan supported with mercury. (A Wassermann taken March 7 was still 15 units and + + + +.) Added severitv of the cough and coryza produced by the giving of large doses of potassium iodide are conditions which must be very undesirable in a case of this sort, both from the extra strain put upon the diseased aorta as well as from the loss of sleep entailed. This case, with its extensive recesses on either side and upward, is one for which the wiring operation would seem to be indicated in the near future.

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September, 1916, No. 3, vol. cliii, p. 348.

THE TRANSPLANTATION OF THE THYROID GLAND IN DOGS.

By Charles Goodman, M.D., F.A.C.S.,
CLINICAL PROFESSOR OF SURGERY, NEW YORK UNIVERSITY.

(From the Physiological Surgical Research Laboratory, New York University.)

Highly organized tissue cannot as yet be permanently transplanted from one organism to that of another. So much may be gleaned from the mass of material presented during the past four years by the various experimental workers in transplantation.

There is much laboratory and clinical evidence, however, that the implantation of large fragments of bony tissue is practicable. Albee reported 253 cases of autografts of bone, a large percentage of which were successes, and he concluded that the bone graft is reliable when taken with its enveloping membranes and contacted with bone. McWilliams has also recently shown the importance of the periosteum in transplanting the larger grafts of bone. Some discussion has arisen, it is true, as to the fate of the bone transplant. Borth now agrees with Axhausen, Phemister, and Lewis that the compact bone of the graft is absorbed and that it is replaced by bone formed by the periosteum and endosteum of the graft. Lewis holds that compact bone dies in the graft because of its physical properties which do not permit rapid enough absorption of serum to maintain the life of the bone until the vascular circulation is reëstablished.

Mauclaire reported five successful results out of a number of failures. He believes that if the successes of Küttner and Lexer in the transplantation of articular fragments taken from the cadaver are multiplied that such transplantations will give much better results than the best of resections. Cohn and Mann reported from their fifteen experiments that isolated bone grafts did not act as foreign bodies, nor were they absorbed after sixty days, even showing a tendency to outgrowth. According to MacEwen, if small grafts of compact bone could be used the bone would live, but, as Lewis stated, this ideal condition is rarely, if ever, secured in bone transplantation.

Lexer reported that although Schoene has carried out successfully skin transplantation in animals of the same litter and the same sex, that he himself has never seen any successful homoplastic skin grafts in man even between close relatives.

Erlacher succeeded in the transplantation of muscles, for after ninety-nine days the electrical tests showed that the transplanted muscles reacted normally to stimulation. But his experiments in the free transplantation of nerves were failures, although restoration of the peripheral part of the nerve took place after section.

FIG. 1.—Dog No. 132. Autotransplantation thyroid with carotid and thyroid vessels. No thrombosis of vessels. Thyroid in normal state of preservation.

Von Hacker has recently implanted the central stump of the accessory nerve directly into the trapezius in a case of paralysis of that muscle as a result of injury to the accessory nerve. The result was excellent.

Stich stated, in 1913, that arteries and veins which have been autoplastically transplanted will retain their vitality and become an integral part of the system. The different layers are microscopically shown to be completely intact, but when transplanted

to different animals, and more especially when transplanted to animals of different species, they show a replacement by the tissues of the body to which they were transplanted.

Parenchymatous organs of a more highly physiological function, such as the kidney, spleen, thyroid, etc., when transplanted into another animal, undergo autolysis and are eventually absorbed. The longest time a kidney has continued to functionate in an animal of the same species is three months (Stich, Ingebrigtsen).

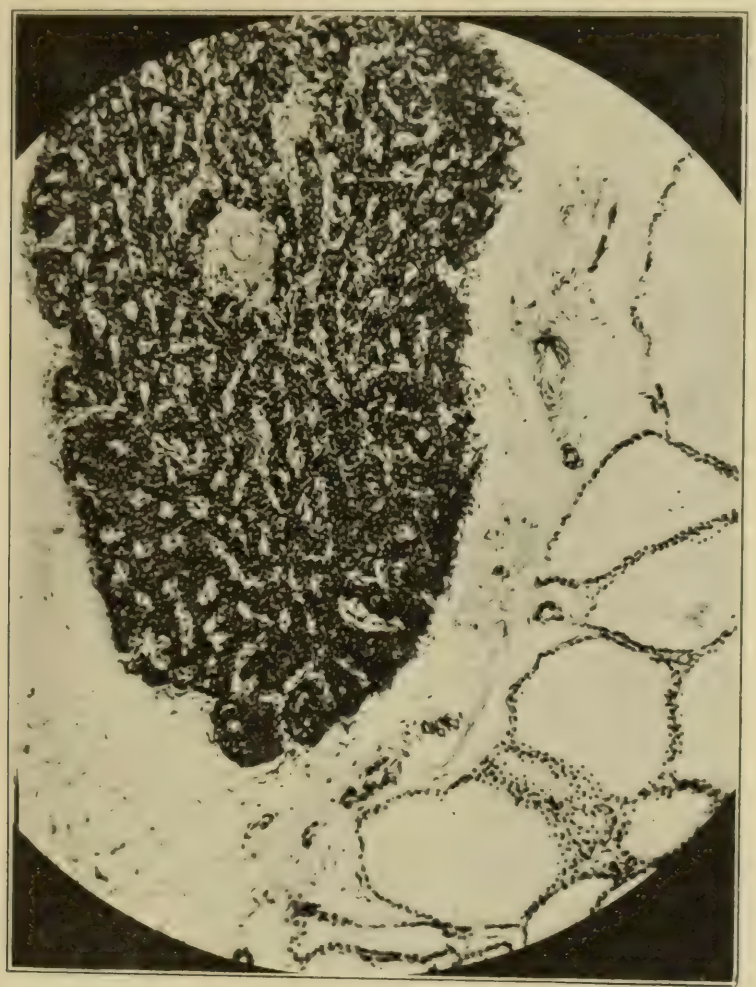

FIG. 2.—Dog No. 142. Homotransplantation of thyroid gland with carotid and thyroid vessels. Shows parathyroid in perfect preservation, but does not show how many oxyphil cells it contains. Vessels preserved in their normal state. Thyroid fairly well preserved.

Nemiloff found in transplantations on dogs that pancreatic tissue transplanted either as autografts or homoplastically, subcutaneously or intra-abdominally is for the most part absorbed in the course of a few days and that a thin zone of living parenchyma remains only at the edge of the transplant. This is more pronounced in homoplastic experiments. The longest interval of survival of any part of the transplant was fourteen days.

Crowe and Wislocki, in their experimental work in suprarenal

glands in dogs, found in several instances normal-looking viable cells of the cortex after transplantation, but the majority of grafts underwent degenerative changes and were eventually replaced by scar tissue; in any event the chromaffin elements entirely disappeared. The authors attributed these changes to the lack of nerve supply to the graft.

Lexer remarked at the International Surgical Congress in New York, 1914, that he had been able to overcome some of the bio-

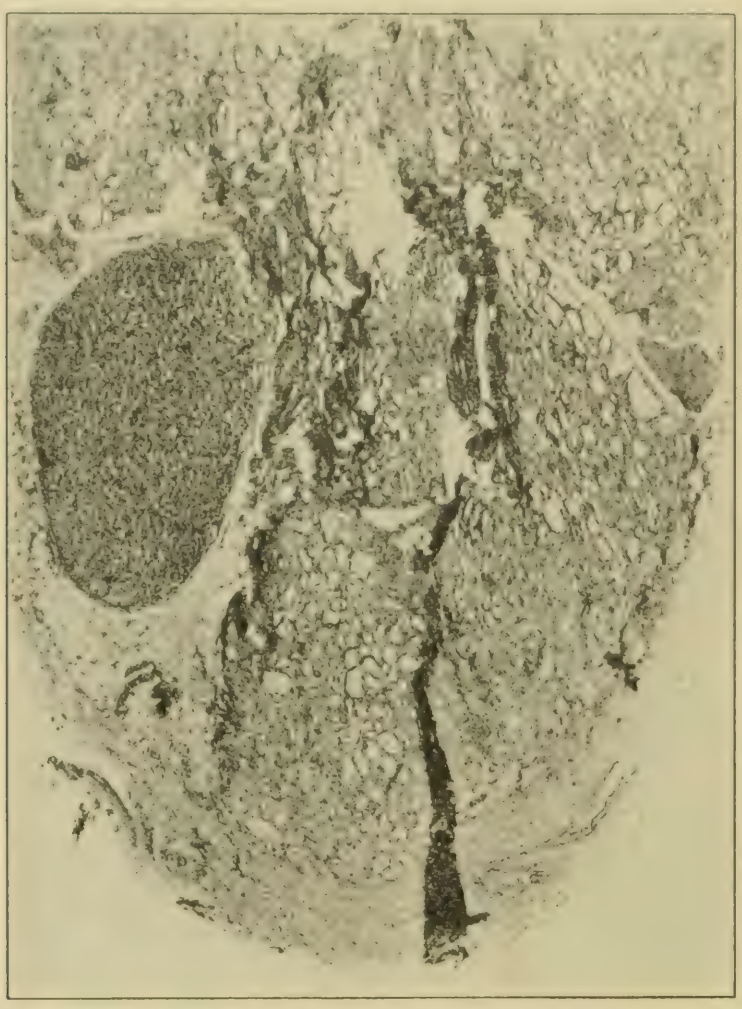

FIG. 3.—Dog No. 199. Homotransplantation thyroid with carotid and thryoid vessels. Colloid absent. Follicles extensively shrunken and destroyed. The parathyroid is not very well preserved, but shows no connective-tissue proliferation nor vessel changes.

chemical differences in animals by prolonged treatment of the host with serum and tissue taken from the donor. By these means skin transplants lasted considerably longer; in some cases even for six weeks. He considered that the prospects of improving homoplastic surgery were most hopeful along this path.

James B. Murphy found that if portions of the spleen were transplanted with the malignant tumor transplant that the growth

of the latter was retarded. He reasoned, therefore, that if the activity of the lymphatic system could be temporarily retarded that the chances for the permanency of the transplant would be materially increased. He suggested either the application of Roentgen rays or the internal administration of benzol for this purpose.

Among the more recent attempts at transplantation in human beings the more remarkable are those of Tuffier, Kocher, Lydston, Payr, and Küttner. Tuffier did 204 ovary transplantations in

FIG. 4.—Dog No. 202. Homotransplantation of thyroid gland with segment of carotid and the thyroid vessels. Parathyroid gland in good state of preservation. Thyroid shows evidences of beginning autolysis.

which the autografts were only successful in women under forty years of age. In 4 cases Tuffier removed human autografted ovaries from two to three years after they were transplanted, and found incontrovertible evidence that they had been functionating. Tuffier concluded, however, that when the uterus is absent, ovarian transplantation is of no value.

G. F. Lydston, in his experiments with the testicle, had surprising results in therapy, but his transplants did not long survive.

Marine has demonstrated on rabbits that specific secretory nerve fibers are not essential in transplants in order that thyroid tissue may exhibit the characteristic morphological and physiological changes known to be associated with great variations in functional activity.

TRANSPLANTATION OF THE THYROID GLAND WITH A SEGMENT OF CAROTID ARTERY

Dog No.		Condition of carotid.	Duration of life.
132	Autotransplant	No thrombosis	23 days
138	"	"	24 hours
142	Homotransplant	"	12 days
147	"	"	14 "
148	Autotransplant	"	4 "
157	Homotransplant	"	44 "
164	"	"	42 "
174	"	"	6 "
186	"	"	10 "
192	"	Partial thrombosis Gland absorbed	79 "
199	"	Thrombosis	4 "
208	"	No thrombosis	2 "
242	"	"	5 "
262	"	"	3 "
269	"	"	7 "
274	"	"	3 "
38	"	"	5 "
58	"	"	10 "
77	"	"	9 "
98	"	"	4 "
107	"	"	5 "
124	"	Partial thrombosis	4 "
180	"	No thrombosis	61 "
191	"	Thrombosis	49 "
202	"	No thrombosis	8 "
225	"	"	21 "
229	"	"	14 "
239	"	Partial thrombosis	7 "
283	"	Gland absorbed No thrombosis	53 "
214	"	No thrombosis	112 "

Theodore Kocher and Payr concluded that thyroid transplantation was much more effective and more rapid than that of thyroid medication, but Kocher believed that one transplantation did not suffice. Kocher also believed that the problem of ensuring the permanency of the transplant might be solved by finding ways of decreasing the recipient's immunity and of performing the transplant in the presence of an infection.

Stich found that thrombosis of the thyroid veins was a menacing factor. When this occurred, some time after the transplantation, there was some chance of vascularization from the surrounding tissue; otherwise the transplant was lost.

With a view of throwing some light on the causes of failure in the transplantation of organs, we chose the thyroid gland for our experiments on account of its accessibility and the readiness with

which it offers itself to reimplantation with a restoration of its circulation by the aid of bloodvessel suture. We found that we were able to overcome the difficulties of venous stasis and thrombosis by adopting the technic already referred to in *Annals of Surgery*, December, 1914. This technic consists briefly in an implantation of the thyroid gland underneath the muscles of the neck and a biterminal suture of a segment of the attached carotid of the severed vessel of the host and end-to-end suture of the thyroid vein with the central end of the external jugular of the opposite side.

During the months of October and November, 1914, we had a series of postoperative hemorrhages. A microscopic examination disclosed a traumatic rupture of one of the lines of suture. Investigation proved that these hemorrhages were brought about by accidental fighting between the animals.

In Case 202 the carotid was smooth, the superior thyroid artery, the thyroid and external jugular veins were patent, and the gland and the transplant were normal in color and appearance. The capsule was smooth and freely movable. Death was due to pneumonia. The pathological report by Professor Symmers was as follows:

"The upper portion of the thyroid reveals the presence of numerous vesicles containing colloid, the interstitial tissues are not increased in thickness, and the gland appears to be normally vascularized. The lower portion of the thyroid shows the presence of a relatively low proportion of colloid-containing vesicles. The majority of the vesicles are empty of colloid. They are lined with a rather low cuboidal epithelium which in many places have undergone proliferation, partially filling the lumen of the vesicle. The desquamation of the epithelium occurs in places. The interstitial tissues do not appear to be thickened. The parathyroid gland is apparently well preserved."

There was not, in the entire series of 30 operations, a single instance of infection. In 12 of these cases, intratracheal anesthesia with the Janeway intratracheal apparatus was used. In the remaining cases ether was administered with an Allis inhaler.

We have had three instances among our homotransplantations in which the parathyroid gland remained in a normal state of preservation while the thyroid gland showed evidences of autolysis. In autotransplantation we have succeeded in two consecutive instances in retaining the thyroid gland in its normal state microscopically. On the transplanted bloodvessels we have made the following observations: In 25 out of 30 instances the segments of the carotid artery remained free from thrombosis and in 4 instances the superior thyroid artery also remained patent and without any evidences of thrombosis, although the gland transplanted has undergone autolysis and was partly absorbed. The histological findings of these specimens will be reported in a subsequent article.

We agree with Stich, Borst, Enderlen, Carrel, Lexer, and Jeger that autotransplantation is practicable. After homotransplantation the transplant of a bloodvessel will retain its life for an indefinite length of time while more highly organized tissue of a more complicated physiological function will remain intact for a short time only, from two to four weeks, and will then show evidence of absorption. In the absence of hemolysis and agglutination the life of the transplant of even more highly organized tissue may be prolonged. We must conclude that up to the present time we have no means of prolonging the life of an organ transplanted from one animal to another indefinitely.

Thanks are due to Dr. I. Seff and to Dr. S. Berkowitz for valuable assistance.

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THE DISINFECTION OF VITALIZED TISSUES AND THE HEALING OF WOUNDS WITH CHINOSOL AND SALT*

BY WILLIAM C. LUSK, M.D.
OF NEW YORK
PROFESSOR OF CLINICAL SURGERY AT THE NEW YORK UNIVERSITY AND BELLEVUE HOSPITAL MEDICAL COLLEGE; ASSISTANT VISITING SURGEON TO BELLEVUE HOSPITAL

THE objective is to bring positive and convincing proofs of the healing value of chinosol in combination with salt.

Chinosol is pure normal oxyquinoline sulphate. *In vitro,* though a powerful antiseptic, it is very little germicidal. A 2 per cent. solution did not kill staphylococcus aureus in twenty-four hours. Its disinfectant action on vitalized tissues is therefore probably due to the excitement by it of physiological stimuli to bring nature's forces of resistance to the fore.

Salt was combined with chinosol by the writer through the influence of the writings of Col. Sir Almroth E. Wright [1] relating to salt in the treatment of wounds.

Clinical Experience.—Examples of cases treated with chinosol and salt are as follows: Primary union in incised wounds, as, for instance, a case of cut tendons of the wrist; cases of acute suppuration, as one of cellulitis of the leg covering an area about the size of one's hand, due to colon bacillus, with sloughing interior, in which, with the use of a solution of 2 per cent. chinosol and 5 per cent. sodium chloride, the opposing surfaces of the abscess cavity were almost completely united on the ninth day; the healing of a whitlow with bone involvement without destruction of the tendons (function returning) and with union of the soft parts to the area of exposed bone, the latter having taken place by the tenth day, using a solution of 2 per cent. chinosol and 0.85 per cent. sodium chloride; the filling with granulations, in about five weeks' time, of a bone cavity about 7 inches in length in an expanded lower portion of the shaft of a tibia, resulting from an operation for osteomyelitis, the whole medullary portion of the bone having been removed, treatment having been by a daily application of gauze wet with a solution of 2 per cent. chinosol and 0.6 per cent. sodium chloride for two hours; the healing of a pelvic fistula 6 to 8 inches in length, by injections, at first daily for one month with a solution of 2 per cent. chinosol and 5 per cent. sodium chloride, with which treatment the fistula became reduced to 2⅜ inches in length, later having been completely closed with the use of

* Foreword to an uncompleted paper read before the N. Y. Surg. Soc., Feb. 12, 1919.

[1] Wright, A. E.: Lancet, 1915, ii, p. 1009; 1916, i, p. 1203; 1918, i, 831.

the tincture of chinosol; the cicatrization of a deep wound entirely encompassing the anus, the result of the separation of a slough, with high retraction of the anus above the skin surfaces of the buttocks, so that in three and one-half weeks' time the anus was pulled down and united even with the surrounding skin, treatment having been by the daily application of gauze wet with a solution of 2 per cent. chinosol and 2 per cent. sodium chloride for about one-half hour; the complete removal of a deep slough filling the base of a large carbuncle of the neck, which had been incised, with the adhesion of the undermined skin edges almost everywhere to the surface of the ulcer underlying them, by the fourteenth day, using a solution of 2 per cent. chinosol and 0.85 per cent. sodium chloride.

A chinosol ointment and a tincture of chinosol have important uses. The ointment (℞ chinosol grains vi, sodium chloride grains ii, lanolin and vaseline āā ʒss) rubbed in for four or five minutes once in two or three hours, has proved a pretty reliable agent with which to abort beginning hair-follicle infections. The tincture (℞ chinosol, 2 per cent., and sodium chloride grains iss to the ounce in 80 per cent. alcohol) applied once a day to the skin around a furuncle, after having removed the grease with a fat-solvent, will prevent infection of neighboring hair follicles.

The technic is simple, application of the chinosol-salt aqueous solution in suppurating and granulating wounds which are accessible being made by means of gauze which, when the wounds are discharging, is left in place between daily dressings, but when the wounds begin to granulate healthily with little discharge, should be removed in two or three hours following the dressing, to permit collapse of the wounds. The solutions used in this class of wounds contain 2 per cent. of chinosol with either 0.85 per cent. or 5 per cent. of sodium chloride. The combination of this strength of chinosol with the hypertonic salt probably promotes cicatrization to a greater degree than does that with the iso-tonic salt, while the latter combination probably promotes the growth of granulations more than does the former. These solutions on contact with the wound cause a burning sensation which quickly passes away.

The healing of blind tracks of soft parts may be facilitated by injecting the tracks once in six or eight hours through tubes having no punctures, introduced to their bottoms, for which purpose the 2 per cent. chinosol solution having the 5 per cent. salt content is probably the preferable solution of the two. The tincture of chinosol (℞ chinosol 2 per cent. and sodium chloride grains iss to the ounce in 80 per cent. alcohol) has seemed particularly advantageous for the healing of blind fistulæ *in ano*, though with a different technic, it being injected into the track two or three times at fifteen to thirty minute intervals each day.

For the control of sepsis in a draining empyema case, the solution of 2 per cent. chinosol with the 5 per cent. sodium chloride content is recom-

ADDENDA

In dispensing the tincture of chinosol according to the formula here given, a heavy precipitate will form when the ingredients are first mixed with the alcohol, which on standing for twenty-four to thirty-six hours, with occasional shakings of the mixture, will almost entirely dissolve. The precipitate, consisting mostly of oxyquinolin, should be allowed to dissolve and should not be filtered off. When in making up the tincture of chinosol, the chinosol and sodium chloride were first dissolved in the requisite amount of water needed to dilute the 95 per cent. alcohol down to 80 per cent., and the 95 per cent. alcohol then added to this solution, the final residue after two or three days was insignificant, which technic of making up this tincture seems to be the best. It requires 9.9 c.c. of water to be added to 45.5 c.c. of 95 per cent. alcohol to make an 80 per cent. alcohol ("U. S. Pharmacopœia"), or 84 minims of water to 396 minims of 95 per cent. alcohol.

ADDENDA

Oxyquinolin is precipitated from the chinosol solutions by an alkali, so that all utensils—vessels, syringes, etc.—with which these solutions are to come into contact, should be boiled in plain water without soda content. Glass vessels are preferable to enameled ones, since areas of bared iron, usually present in the latter, will discolor a chinosol solution.

mended, one ounce of which may be injected into the cavity daily, to be retained by posture, following preliminary washing with salt solution. In one case the use of a 5 per cent. salt solution for the preliminary washing seemed to avail more toward cicatrization and healing of the wound than had normal saline. Wright has shown that a preliminary wash of a pus-secreting surface with physiological salt solution to remove the albuminous substances, gives an after-coming antiseptic an opportunity to reach the bacteria. Before dressing a wound, the surrounding skin is first wiped with McDonald's solution (alcohol 60 parts, acetone 40 parts, to which 2 per cent. of pyxol is added).

First-aid treatment is effected either by packing the wound with gauze saturated with a solution of chinosol iv grains to the ounce and 0.85 per cent. sodium chloride, which may be left in place for twenty-four hours before repairing or redressing the wound, when the same solution should be used again, or by simply sponging the wound freely with the solution during the operation for its immediate repair. The above gauze pack, after remaining in a fresh wound for twenty-four hours, often adheres to well-nourished tissues. Hypertonic salt should not be used in a fresh wound which is to be sutured.

In both old and fresh wounds which gape, it is advisable to interpose a piece of rubber tissue between the gauze which brings the chinosol salt solution into contact with the wound and the external dressings, in order to prevent abstraction of the solution into the latter.

Animal experimentation was done to prove the value of chinosol as a first-aid disinfectant. In the animal experiments the wounds were constructed as pockets between the superficial and deep layers of the superficial fascia in a dog's back. These pockets, when made blood-free, would absorb the solution very freely no matter what was the strength of the salt, but when the tissues were infiltrated with blood the absorption of the solution would be slower or sometimes there would be none at all.

The instances in which primary union followed the disinfection of a scientifically infected wound, where the infection preceded the disinfection, were not frequent. One case which gave encouragement to the work was that of a dog infected with staphylococcus aureus, having used as much of a twenty-four hour culture as could be taken up by a piece of gauze about 1 by 1¼ inches square, crumpled up, which was left in the wound for thirty minutes, the wound then being disinfected with a solution of chinosol grains vi to the ounce and 0.6 per cent. sodium chloride, in which primary union took place in the disinfected wound, while from the control wound on the opposite side an extensive cellulitis developed, which resulted in a large area of superficial necrosis with ulceration extending from near the backbone forward to the anterior median line.

In a recent series of experiments consisting of 12 dogs, in which the lymphatics leading from *wound pockets* between the layers of the superficial fascia, *uncontaminated with blood,* were first infiltrated with the disinfectant

solution before infecting the wounds for thirty minutes with as much of a virulent twenty-four hour culture of staphylococcus aureus as could be absorbed on a piece of gauze about half an inch square, crumpled up, and the disinfectant solution was applied to the wounds again following the infection, the wounds having been finally sutured primarily, these same wounds in seven of the animals united by primary union, while the controls all suppurated. The strengths of chinosol used in this series of animals were grains iv and vi to the ounce, and 2 per cent., and of sodium chloride, 0.85 and 0.6 per cent.

In two similar experiments with *blood-infiltrated wounds,* in which solutions of chinosol grs. vi to the ounce in combination with 0.6 per cent. and 0.85 per cent. sodium chloride respectively, were used, each of the wounds thus treated exhibited an area of dark gray staining of its fatty interior, due to a change produced in the infiltrated corpuscles in the course of from fifteen to thirty minutes by the action of the chinosol, and both of the wounds suppurated, pure staphylococcus aureus having been found in the pus from each, while the control wounds, also infiltrated with blood, both united by primary union. These results led to a study of the action *in vitro* of solutions of chinosol and salt, on washed blood corpuscles. In this connection, it is of interest that two *sterile* blood-infiltrated wound pockets in the subcutaneous tissue of a dog, treated with a solution of 2 per cent. chinosol in combination with salt, with resulting areas of dark gray and gray-black staining, following primary suture, united by primary union. With the use of the first-aid solution(chinosol grs. iv to the ounce and 0.85 per cent. sodium chloride) in experimental wounds into which blood had flowed, a smoky yellow color and occasionally a light grayish tinge have been noted, usually affecting the loose connective tissue joining together the superficial and deep layers of the superficial fascia, which at the same time has become the seat of an œdema resulting from an infiltration of it by the solution. In fresh traumatic wounds, staining of the tissues attendant upon the use of the first-aid solution has, in a limited experience, not been a feature.

These experiments have shown that the production in fresh wound pockets uncontaminated with blood, of immunity to scientific infection with a large number of virulent staphylococci aurei, by the use of chinosol with iso- and slightly hypo-tonic salt and once by the use of 2 per cent. chinosol alone, has been accomplished in a majority of the instances, which furnishes *proof* of the disinfectant action of chinosol on vitalized tissues. The practical application of this knowledge would be to the first-aid treatment of wounds. Thus it would seem that, if fresh traumatic wounds could, within the first few hours of their receipt, at a time when, as Carrel and Dehelly have shown, bacterial growth has hardly begun, have their open lymphatics blocked with a solution of chinosol and iso-tonic salt, com-

parable to the lymphatic block with the disinfectant solution preceding the scientific infection with a large number of virulent bacteria in the dog's wounds, that immunity of these wounds, at least to the ordinary pus germs, in the presence of a but comparatively trivial amount of infection at this early period, could similarly be expected. The lymphatic block of a fresh traumatic wound with chinosol and salt should be superficial, since in the animal experiments an extensive infiltration of the solution into the lymphatics opening into a wound, following scientific infection of the latter, seemed many times to have been the probable cause of extending the infection to a distance from the site of its implantation. Although blood infiltration associated with the use of the chinosol salt solution as described, might be incompatible with the production of immunity against a severe scientific infection in an experimental wound closed by primary suture, yet this same condition would not necessarily be incompatible with producing a lymphatic block against the invasion of the tissues by bacteria or with arresting bacterial growth, in a traumatic wound treated open by the introduction into it of gauze packing saturated with the disinfectant solution, especially when the latter is introduced early before the bacteria have begun to multiply greatly.

Twenty-four grains of chinosol in solution have been infiltrated into the lymphatics of a sterile, fresh wound in the back of a dog weighing 8 kilos, with primary union and without complication.

Miss W. Carey Noble, of the Research Laboratory of the New York Board of Health, has made very careful bacteriological tests with chinosol, which virtually confirm the tests of the Council on Pharmacy and Chemistry [2] of the American Medical Association.

Dr. Alexander O. Gettler, pathological chemist to Bellevue Hospital and to the City of New York, has done important work on the chemistry of chinosol to incorporate in this report.

Mr. Pro. V. Prewitt, Instructor in Physiology at the New York University and Bellevue Hospital Medical College, has done a valuable piece of work on the action of chinosol alone, and in combination with salt, on blood corpuscles.

The merits of chinosol in combination with salt as a tissue disinfectant can be summarized as follows: Its stability, its ease of application, its applicability to first-aid treatment of wounds, its tendency to dry up pus, its non-irritability when applied in accordance with the technic here advocated, unless possibly after prolonged use; also the facts that it appears not to attack tendons and that it facilitates the separation of sloughs.

[2] Report on Chinosol of Council on Pharmacy and Chemistry, American Medical Association, Journ. A. M. A., 1910, liv, p. 1801; editorial, p. 1790.

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